Goal 4: Increase understanding of construction sector attributes that affect occupational safety and health outcomes

Most Construction Program research addresses the three previous goal topics. However, injuries, illnesses and disorders do not occur in a vacuum. It is necessary to thoroughly understand sector-specific attributes and contributing factors to understand obstacles to and opportunities for prevention. We have encouraged and supported research to increase such understanding. Gains in knowledge and technology in this area can be applied to improve interventions and strategies for illness, injury, and exposure-reduction goals.

By their nature, the topics discussed in this section have some overlap with earlier topics. For example, improving surveillance resources is a topic in this section. Whereas surveillance research mentioned in previous subgoal sections focused on the hazard-specific surveillance studies, the research mentioned here relates to broader issues such as evaluating new surveillance ideas, characterizing the industry for a particular issue, or looking at the reliability of surveillance systems across construction. The activities and outputs described here are focused on improving research and practice tools and methods so that the outputs of research in other areas are a) easier to achieve, and b) more efficiently transferred to the workplace.

Sub goal 4.1 Use and improve surveillance resources to identify and track construction safety and health risk

A) Issue

Surveillance provides a foundation for safety and health research, and most of the preceding sub goal narratives in this report begin with description of surveillance research related to a specific outcome. The purpose of this sub goal is to describe work undertaken to improve overall surveillance capacity for construction research and to address cross-cutting surveillance issues and activities.

Prior to the creation of the Construction Program, early NIOSH surveillance efforts such as the National Occupational Hazard Survey (NOHS), the National Occupational Exposure Survey (NOES), the National Occupational Mortality Surveillance (NOMS), and the National Traumatic Occupational Fatalities (NTOF) surveillance program all included construction and produced information to inform construction research [NIOSH 1974; 1977a,b; 1988; 1989a,b]. For example, the NOES identified construction as the leading industry whose workers were most at-risk for asbestos exposure, and NTOF data confirmed that construction had the highest fatality count and second highest fatality rate per 100,000 workers. In 1987, the National Academy of Sciences Panel on Occupational Safety and Health Statistics recommended the development of a more comprehensive national database on occupational fatalities and their causes [Pollack and Kiemig 1987]. This led to the development of the BLS Census of Fatal Occupational Injuries (CFOI) system, a multiple-source data set that became operational in 1992. In 1989, NIOSH NOMS data recognized that construction trades were experiencing high risk for occupational cancer, lung and heart disease, and fatal injuries [Robinson 1989].

In 1990 and again in 1991 Congress directed NIOSH to develop “surveillance data to identify and monitor emerging hazards in the construction industry,” and improving the collection, analysis, interpretation, and use of surveillance data was an early focus of the Construction Program [NIOSH 1995]. This led to a number of intramural and extramural research activities during the early years of the Construction Program. Building surveillance capacity was also integral to the Construction Center cooperative agreement awarded in 1990 and again in 1995. The purpose for the Center was to “support a center that demonstrates effective surveillance mechanisms and prevention processes that are efficacious and effective in preventing injuries, disabilities, and diseases associated with work in the construction industry” [NIOSH 1995].

Over the past two decades, Construction Program and Center researchers have collaborated with NIOSH Surveillance Program researchers and built relationships with various state and federal agencies and academic institutions to develop a national construction surveillance capacity. This capacity has been

used to expand the body of knowledge about the injury, mortality, and illness experience of construction workers. Surveillance findings have served to raise awareness among construction stakeholders and to provide input to guide intervention researchers toward the most important risks. Construction surveillance researchers have also improved understanding of the strengths and biases of existing surveillance systems for understanding true risks to construction workers.

B) Activities

Develop a Construction Data Center

Cooperative agreements with the Construction Center since Program inception have included a requirement to gather in one location available data from national, state and local data sources (including private sector data such as workers' compensation, health insurance and pension information). This involved establishing agreements with data providers such as the BLS for access to data. The scope of the information collected included "denominator" information to help describe and increase understanding of the construction industry and workforce (industry structure, labor market, employment patterns, demographic surveys), along with "numerator" information describing injury, illness, and mortality outcomes.

Once these data were collected and ongoing relationships were created to maintain the databases, they were made available to Construction Program researchers.[1] The Construction Center then began development of a Construction "Chart Book" to organize and communicate the data and to describe occupational injury and illness patterns in a format for use by researchers and stakeholders. Construction Center staff provide technical assistance to government agencies (both domestic and international), and provide information to health departments and researchers inquiring about construction industry statistics.

Evaluate Injury, Illness, and Mortality Patterns for Construction Trades and Tasks

Construction Program and Center researchers performed studies to identify injury and illness patterns and causes of death across all of the construction trades. Both population and case-based surveillance tools were developed to: 1) define construction sub-populations at elevated risk of disease and injury, 2) estimate the magnitude, distributions, and trends in work-related injuries and illness among these populations, and 3) generate hypotheses that may lead to a better understanding of causes of injury among construction workers and possible means of prevention. Resulting studies helped direct intervention and prevention activities to high-risk tasks and trades.

[1] The information is accessible via technical assistance requests to the Center. The Center negotiates memorandums of understanding with the data owners to agree to protect the confidentiality of the underlying data.

Survey Exposure Risks. Construction Program and Center researchers have performed studies to characterize exposures that are associated with injury, musculoskeletal and chronic health risks. These studies have been industry-wide using national data sets, worksites, and tasks performed on worksites, and have performed using national data sets, on-site investigations, and laboratory experiments. They have led to the identification of the major risk factors included in sub goals 1, 2, and 3 in this report, and are summarized at the start of each of the sub goal narratives (see e.g., 2.1 Noise or 2.2 Lead).

Mortality Studies. In 1990, the Construction Program initiated Proportionate Mortality Ratio (PMR) studies using data from 12 AFL-CIO construction trades unions, which were completed and published from 1995 to 1997. In most cases, for example for construction laborers, these were the first mortality studies performed that examined a specific construction trade group [Stern et al. 1995], and they identified many unique hypothesis-generating risks [Steenland and Palu 1999; Burkhart et al. 1993; Robinson et al. 1996]. Construction Center researchers also evaluated mortality using state records [Wang et al. 1999].

Injury Studies. Construction Program and Center researchers have examined construction worker injury experiences using a variety of sources such as workers' compensation data sets [Dement and Lipscomb 1999], hospital emergency department data [Hunting et al. 1999], owner controlled insurance data [Lowery et al. 2000], and emergency room data collected by the Consumer Product Safety Commission (CPSC) [Jackson 2006]. These studies provide important risk factor findings and have improved understanding of the value of these types of data for construction surveillance purposes. Other approaches have targeted specific concerns such as machinery-related fatalities [Pratt et al. 1997], crane-related fatalities [Suruda et al. 1999], fatal and nonfatal injuries from pressurized vessels [Welch et al. 1999], and toxic inhalation fatalities [Dorevitch et al. 2002].

Occupational Illnesses. Traditional sources of occupational safety and health data are unreliable for occupational illnesses. Therefore, alternate strategies have been explored. A number of illness-specific projects were initiated and these are described under Goal 2 (see e.g., sub goal 2.1 Noise or 2.2 Lead). In addition, the Construction Center began to identify and access national data sets not traditionally used for occupational health surveillance for use in describing patterns of occupational illnesses, such as the Medical Expenditure Panel Survey (MEPS), which can be linked to the National Health Interview Survey (NHIS). In addition, Construction program researchers evaluated exposures associated with certain operations as a surrogate or supplemental approach to surveillance. For example, exposure assessments were performed for residential construction and relatively new unstudied operations such as seismic retrofitting operations [McKernan 2000, 2002].

Evaluate the Reliability of Existing Surveillance Systems Used for Construction

All surveillance systems have their strengths and limitations. Developing research studies to identify and understand limitations is challenging, but important for confident use of surveillance results especially when used for judging performance and impact. The most important findings from these studies have been the failure of national surveillance systems to capture illness data and identification of large and growing underreporting of injury data throughout the industry, particularly in the BLS data. [Glazner et al. 1998; Welch et al. 2007].

C) Outputs and Transfer

(See Appendix 4.1 for complete listing of outputs and transfers)

Construction Data Center

Outputs include the development of four databases and several publications as described below:

- *Construction Safety Database* is composed of detailed injury and illness statistics since 1992 and is obtained from the BLS CFOI and SOII data and from the NIOSH Fatality Assessment and Control Evaluation (FACE) reports.

- *Construction Industry Database* is a collection of construction industry economic and market indicator data from multiple data sources that are used to characterize particular sectors or subpopulations within the industry.[2] For example, these data can support estimates of the trades involved and respective labor hours for building a highway or residential houses.

- *Construction Workforce Database* holds data from several household and establishment surveys.[3] Statistics from this database are used as denominators to calculate fatal and nonfatal injury rates, and provide detailed information on age, gender, education, race/ethnicity, unionization, occupation, wage rate, hours worked, family income, benefits, and apprenticeships.

[2] Economic Census; Survey of Minority-Owned Business Enterprises; County Business Patterns; Value of Construction Put in Place; Expenditure for Residential Improvement and Repairs; Total Assets, Trade or Business Income and Deductions; Portfolio Income, Rental Income and Total Net Income in Construction; Construction Data from Dun & Bradstreet Corporation; Construction Market Trends from F.W. Dodge; and data from multiple years of the Statistical Abstract of the United States.

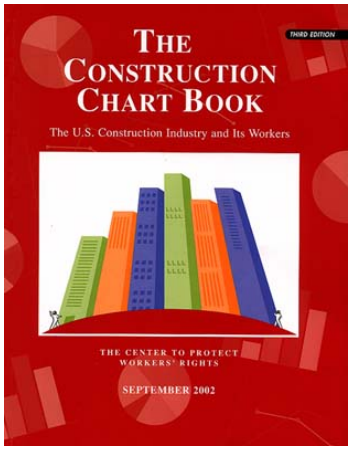
[3] Monthly CPS, March CPS Annual Demographic Files, CPS Contingent Work Supplement, CPS Internet and Computer Use Supplement, CPS Work Schedule Supplement, National Longitudinal Survey of Youth, the Survey of Income Program Participation, Panel Study of Income Dynamics, American Community Survey, Longitudinal Studies of Aging, the Current Employment Statistics, Occupational Employment Statistics, and the National Compensation Survey.

- *Construction Health Database* includes gathered data used for analysis of presumed non-work-related medical diagnoses to determine how they differ among the trades as well as how they differ from the diagnostic distributions in the general population in order to monitor occupational health among construction workers.[4]

- *Construction Overview Publications.* Relying on the surveillance findings, in the 1990s a number of overview publications were completed to begin to explain this complex industry from a safety and health perspective [Ringen et al. 1995b,c], as were the first epidemiological study using medical claims data from a group health plans [Pollack and Ringen 1993], the first reference work for health professionals [Ringen 1995a], and the first overview article aimed at informing developing countries [Ringen et al. 1998].

- *The Construction Chart Book, The U.S. Construction Industry and Its Workers* is a 64-page book first published by the Construction Center in 1997. Additional editions were published in 1998 and 2002 [Grob et al. 1997, 1998; Dong 2002]. The Construction Chart Book*,* also available online, is intended for anyone interested in the construction industry, from decision makers to researchers, paying special attention to occupational safety and health. More than 10,000 hard copies have been distributed, and thousands of electronic versions have been downloaded from the Internet. The Chart Book provides detailed statistics to characterize the construction industry and its workforce, tracks trends and patterns of construction injuries and illnesses, and highlights the impact of the changes in industry and demographics on the safety and health of construction workers. The current version, the third edition, contains more than 170 figures and tables, based on a broad range of sources. Presentations to construction stakeholders describing trends and changes are provided as each new edition is published.

[4] NHIS, MEPS, the Health and Retirement Study, the National Hospital Ambulatory Medical Care Survey, the National Health and Nutrition Examination Survey, and the National Employer Health Insurance Survey. Additional datasets include medical care claims data from laborer health and welfare funds – the Northwest Laborers in Washington State and the Massachusetts Laborers, Washington State workers' compensation data, and access to ULLICO medical care claims data from 25 local construction health and welfare funds.



Evaluate Injury, Illness, and Mortality Patterns for Construction Trades and Tasks

Numerous cross-cutting surveillance outputs have been delivered by Construction Program and Center researchers over the last decade and a half. These include 15 peer-reviewed journal articles describing the results of mortality studies, which in turn have resulted in hypotheses that lead to numerous additional worksite studies. More than 21 peer-reviewed journal articles were published on other injury and illness surveillance studies and more than 45 presentations were made to report on these results to OSHA, labor and trade union meetings, trade association meetings, and professional symposiums. For example, in 1997 significant findings and implications of the Carpenters Union Mortality Study and a preliminary report of *Focus on the Facts: Working with the Workers*, were presented by Construction Program staff to the Advisory Committee on Construction Safety and Health (ACCOSH) in Washington D.C. Construction Program researchers also presented the mortality findings to focus groups consisting of union officials, apprenticeship trainers, and workers. For example, a session titled *Focus on the Facts: Working with the Workers* was arranged in 1997 with Sheet Metal industry representatives and a session the same year titled: *What's killing carpenters? Injury and illness prevention for the future* was arranged with representatives from the United Brotherhood of Carpenters and Joiners of America (UBCJA). A presentation on this pilot intervention was published [Alterman et al. 1999].

Reliability of Existing Surveillance Systems used for Construction

Construction Program and Center researchers authored nine peer-reviewed journal articles and presented six times at professional safety and health conferences describing the results of studies conducted at the Denver International Airport. For example, Center researchers gave presentations describing construction injury risk factors and injury rates at the International Conference on Occupational Health in 1996 and five times at the National Occupation Research Symposium in 1997 and 2000.

D) Intermediate and End Outcomes

Construction Data Center and Chart Book

Researchers, stakeholders, construction contractors, trade associations, and other organizations nationwide and abroad have cited and used Construction Data Center information in their conferences, publications, and websites. Data requested frequently include fatal and nonfatal occupational injury and illness rates, numbers of construction employment and establishments, wage rates, hours worked, union density, health insurance coverage, occupational distribution in construction, construction value and productivity, and other demographic and industrial information in construction. Table 4.1 provides examples of organizations that have requested and used data center information. It has been translated by users into French, Spanish, Japanese, and other foreign languages. Google Scholar shows 73 exact matches of professional publications citing the Chart Book and Google Books shows 20 books referencing it.

Table 4.1 Construction Organizations using the Construction Data Center and/or Chart Book

Construction Unions

The International Brotherhood of Electrical Workers (IBEW) distributed the Chart Book in its 2003-2006 Construction & Maintenance Annual Conference. The IBEW website includes a link to the Chart Book. The 2002 edition of the Chart Book, with updated information on electrical workers, was included on a CD-ROM distributed to 1,000 delegates to the IBEW 2005 Construction and Maintenance Conference.

Construction Associations

The Building Futures Council Chairman, Hugh Rice, cited statistics from the Chart Book in his keynote speech, "Trends and Emerging Issues in the Construction Industry," http://www.irmi.com/Conferences/Crc/Handouts/Crc25/Tuesday/TrendsAndEmergingIssuesInTheConstructionIndustry.pdf.

Construction Latino put the requested statistics on the internet, www.elconstructorlatino.com.

FMI, a large provider of Management Consulting and Investment Banking, cited statistics from the *Chart Book* in its U.S. Market Overview, http://www.fminet.com/global/Articles/USMarketsOverviewSect2.pdf.

Construction Contractors/Management/Engineering

The National Electrical Contractors Association serves the management interests of the entire technical contracting industry and uses safety and health statistics from the *Chart Book*, http://www.necanet.org/.

Safety and Health Professionals

Certified Safety and Health Manager Exam Preparation provides a reading list of materials to master the body of knowledge recognized as appropriate for safety managers and includes the Chart Book.

Researchers

U.S. Army Corps of Engineers Construction Engineering research laboratories cited the safety information from the *Chart Book* in its report, http://www.cecer.army.mil/techreports/kir_cttc.ple/KIR_CTTC_PLE.post.pdf.

Educators

College of Technology and Computer Science at East Carolina University, http://www.tecs.ecu.edu/cm-dept/construction_industry_webpage.html This college links its website to *The Construction Chart Book* and recognizes the Chart Book as one of the major data sources (e.g., BLS, Census) for the nation.

International organizations

Research Institute of Construction and Economy conducts research on public investment and the construction industry in Japan. It uses the *Chart Book* as a major data source to the U.S. construction industry and has translated the Chart

Book (2002 version) into Japanese. See http://www.riceusa.org/pdf/j-report-usconstructionfirm.pdf.

Construction Industry Board (CIB), UK, International Council for Research and Innovation in Building and Construction, http://www.cibworld.nl/website/newsletter/20053.php cited the data from the Chart Book in its conference paper, "The issue of labor shortages in the U.S. construction industry," http://www.ril.fi/Resource.phx/seminaari/semi-cib2005/meetings.htx.i667.pdf.

Ontario Construction Secretariat, Canada represents the 25 Employee and the 25 Employer Bargaining Agencies of the unionized industrial, commercial, and institutional (ICI) sector of Ontario's construction industry. It uses the Chart Book as a major data source in its report, "ICI constitution in Ontario: A review of competitive disadvantage and its measurement," http://www.iciconstruction.com/site/pdf/ICIConstructionOntFinal05282002.pdf.

Government
Standard Technology (NIST), http://www.bfrl.nist.gov The Chart Book is cited by the Office of Applied Economics Building and Fire Research Laboratory in its report, "An Approach for Measuring Reductions in Operations, Maintenance, and Energy Costs for Educational Facilities," NISTIR 6770, http://www.bfrl.nist.gov/oae/publications/nistirs/6770.pdf.

The data center and outputs have also facilitated identification of construction industry developments of broader public policy interest above and beyond safety and health. For example:

- *Independent contractors*. The rise of construction workers employed as independent contractors was first described by CPWR 1994. It showed that such employment had increased from 7% to more than 20% over a period of 20 years, with significant implications for safety and health and surveillance. This information has since been used by building trades and employer organizations to argue for legislative and policy changes. Congress is now addressing this issue[5] and in a number of states (e.g., Washington State has established a commission).
- *Hispanic workforce*. The explosive growth of Hispanic workers in the construction industry since NAFTA, and the higher risk of injury that these workers face, was first reported in 2004 [Dong and Platner 2004], which led to interviews on public radio and presentations to Congress.

Evaluate Injury, Illness, and Mortality Patterns for Construction Trades and Tasks

Surveillance studies performed by Construction Program and Center researchers have provided important inputs for follow-up activities by stakeholders and other researchers. For example, Google Scholar shows 170 exact matches of professional publications citing the construction union mortality studies and Google Books shows three books referencing them.

Mortality Studies: Findings from the early PMR studies generated important hypotheses that led to more extensive studies and preventive measures. For instance, they established, for the first time, that construction trades are high-risk groups that should be under active occupational medicine monitoring (which is still not the case except in special circumstances e.g., hazardous

[5] There was a Congressional hearing on it most recently on March 27, 2007.

waste remediation or employment in DOE facilities in special circumstances). These mortality studies also discovered the risk for struck by injuries in highway work zones.

Injury Studies: In addition to surveillance findings using workers compensation data in North Carolina, researchers identified a nail gun injury hazard to construction workers. Based at least in part on this finding, the International Staple, Nail, And Tool Association (ISANTA) and the American National Standards Institute (ANSI) investigated interventions to address this issue; specifics can be found in Goal 1.3 Struck by Incidents Involving Vehicles, Equipment, and Tools. Through a grant from the Construction Program, the Duke Health and Safety Surveillance System was developed and implemented to provide comprehensive health and safety surveillance for more than 20,000 health care workers.

Based upon injury data collected at the George Washington University, Emergency Department in Washington, D.C., the Mechanical Contractors Association of America used the trade-specific results for electricians, plumbers, and sheet metal workers to develop a new eye injury prevention program [MCERF 2000].

Reliability of Existing Surveillance Systems used for Construction

The major strengths of the existing surveillance systems are that data are released more quickly than before. There are convenient internet query databases and links (CFOI, SOII, Work-RISQS /NEISS, FACE, etc.); detailed information on event, injury source, and part of body (CFOI, SOII, FACE, NEISS, etc.); and standardized instruments (most datasets except FACE).

Google Scholar shows 70 exact matches of professional publications citing the surveillance research conducted by Construction Program researchers at the Denver International Airport and Google Books shows five books referencing it. Construction Program research efforts at the Denver International Airport study resulted in: (1) additional studies to improve upon information collection methods from workers' compensation claims to capture critical data that could lead to improved injury prevention activities, as well as training of safety professionals to capture the factors that contributed to each injury in their periodic assessments of site safety; (2) the development of baseline measures for reducing construction injury and illness by the National Institute of Standards and Technology [Chapman 2000]; and (3) the Denver International Airport construction manager used study findings in their subsequent safety management practices.

E) External Factors

The focus of Construction Program and Center surveillance experts has been to maximize the use of existing traditional surveillance resources for evaluating construction problems and to evaluate the value of other less traditional sources.

This work has led to identification of limitations in current sources and interest in improving current systems.

However, with the exception of FACE, these data systems are owned by groups other than NIOSH and this presents challenges to making changes to improve current systems. National surveillance systems are by their nature expensive and this is an additional external factor to improving surveillance capabilities. Construction Center researchers were invited to share perspectives on limitations in current systems at a July 2005 National Academies meeting on data sources and limitations for construction safety and health research. Limitations shared with the committee were as follows:

- Lack denominators (No linkage between injury/illness data and workforce data)
- Incomplete data (e.g., SOII excludes self-employment and government workers)
- Lack information on industry and occupation (e.g., Work-RISQS /NEISS, NAMCS, NHAMCS, NHANES)
- Missing data (e.g., FACE, SOII, CFOI)
- Limited information on occupational illnesses (e.g., SOII, CFOI)
- Non-randomly selected data (e.g., IMIS)
- Non-standardized data (e.g., FACE)
- Outdated data (e.g., NHIS Occupational Health Supplement, NOES)
- No information on effects of safety training
- No information on working environment and work organization (e.g., no workload and union status in CFOI and SOII)
- Gap in historical data under different coding systems (e.g., NAICS vs. SIC)
- No productivity and cost measures, and
- Difficulty to obtain access to microdata

Current systems do not currently provide sufficient information on either musculoskeletal disorders or occupational illnesses. These are important outcomes and are costly. For example, early studies of the experience from other countries (e.g., Sweden), national workers' compensation systems established that by far the greatest and most costly risks in construction were musculoskeletal in nature [Holmstrom et al. 1995].

F) What's Ahead?

The Construction Program developed a draft strategic goal for surveillance in 2005. It includes draft intermediate goals to make improvements in current systems; develop alternative approaches such as exposure databases to supplement limited health surveillance systems; and promote surveillance activities among stakeholders at the organizational level. The NORA Construction Sector Council also selected surveillance as a top problem, and the

group is currently developing draft strategic goals to address surveillance needs over the coming decade.

Specific project related activities underway include the following:

Construction Data Center
The Construction Chart Book: The Construction Industry and Its Workers, Fourth Edition will be published in fall 2007. This fourth edition will expand the safety and health section with more topics and detailed statistics, including:

- Effects of NAICS and other data system changes on safety and health statistics
- Job openings, hires, and separations
- Foreign-born workers/immigrants
- Time used and hours worked
- Injury rates by demographic, employment category (age, race/ethnicity, foreign-born, size, length of service), and state
- Costs of occupational injuries by construction industry and occupation
- Hazards and work-related illnesses, selected states

NIOSH plans to develop a system to automate the coding of industry and occupation. For the years 2003-2004 mortality data from 10 states that code industry and occupation will be added to the NOMS database.

Intranet and Internet websites are under development that will allow the user/requestor to directly access the analytical results. Results for individual states and for the all states combined are to be made available in the near future.

Injury, Illness, and Mortality Patterns
There are two new grant-funded projects in process. The first project is an active surveillance effort for falls among residential construction workers. The second project is evaluating the impact of the ANSI voluntary standard and worker training in the prevention of injuries from pneumatic nail guns.

Construction Center staff are currently conducting research into the identification of exposures or agents associated with increased COPD risk among construction workers. Collaborators include the Sheet Metal Occupational Health Institute Trust (SMOHIT), CPWR, and Duke University.

Construction Program researchers are currently using California Cancer Registry data for construction worker cancer patients to investigate annual incidence rates and PIRs for total cancer and for major cancer sites in the construction industry as a whole and for major occupations in the construction industry. The project may reduce cancer morbidity and mortality by monitoring trends in cancer among construction occupations, encouraging those workers in occupations with increased cancer to reduce modifiable risk factors (e.g., smoking cessation) and

have appropriate cancer screening tests, and adopting policies and practices to reduce carcinogen exposures.

In 2006, a NORA project was funded to identify performance metrics for construction safety and health. A model set of indicators will be developed for small, medium, and large contractors to evaluate their progress in reducing injuries and illnesses.

References

Alterman T, Robinson CF, Sieber WK, Durst J [1999]. What's killing carpenters? Injury and illness prevention for the future. Proceedings of the 2nd International Conference on Implementation of Safety and Health on Construction Sites, A.A. Balkema Rotterdam.

ANSI [2002]. American national standard for power tools—portable, compressed-air–actuated, fastener driving tools—safety requirements for, ANSI SNT-101-2002 (Revision of ANSI SNT-101-1993). LaGrange, IL: American National Standards Institute; International Staple, Nail, and Tool Association; 2002. [http://www.isanta.org/snt101__new.pdf]. Date accessed: May 2007.

Burkhart G, Schulte PA, Robinson CF, Sieber WK, Vossenas P, Ringen K [1993]. Job tasks, potential exposures and health risks of laborers employed in the construction industry. Am J Ind Med *24*:413-425.

CDC [2007]. Nail-Gun injuries treated in emergency departments - United States, 2001--2005. MMWR *56*(14):329-332, 2007.

Chapman R [2000]. An approach for measuring reductions in construction worker illnesses and injuries: Baseline measures of construction industry practices for the national construction goals. NISTIR 6473. U.S. Department of Commerce, Technology Administration, National Institute of Standards and Technology.

Dement JM, Lipscomb HJ [1999]. Workers' compensation of North Carolina residential construction workers: 1986-1994. App Occup Env Hyg *14*:97-106.

DHHS [2000]. Healthy Vision 2010. National Eye Institute, National Institutes of Health, Department of Health and Human Services. [http://www.healthyvision2010.org/index.asp]. Date accessed: April 2007.

Dong X, Chowdhury R, McCann M, Trahan C, Gittleman J, Seegal J [2002]. The construction chart book: The U.S. construction industry and its workers, 3rd Ed. MD: The Center to Protect Workers' Rights.

Dorevitch S, Forst L, Conroy L, Levy P [2002]. Toxic inhalation fatalities of U.S. construction workers, 1990 to 1999. J Occup Environ Med *44*(7):657-662.

Glazner JE, Borgerding J, Lowery J, Bondy J, Kreiss K [1998]. Construction injury rates may exceed national estimates: Evidence from the construction of Denver International Airport. Am J Ind Med *34*:105-112.

Grob H, Poor T, Dong X, Lemen R, Pollack E, Schneider S, Seegal J [1997]. The construction chart book: The U.S. construction industry and its workers, 1st Ed. MD: The Center to Protect Workers' Rights.

Grob H, Dong X, Pollack E, Schneider S, Seegal J [1998]. The construction chart book: The U.S. construction industry and its workers, 2nd Ed. MD: The Center to Protect Workers' Rights.

Holmstrom E, Moritz U, Engholm G [2005]. Musculoskeletal disorders in construction. Occupational Medicine: State of the Art Reviews *10*(2):295-312.

Hunting KL, Welch LS, Nessel-Stephens L, Anderson J, Mawadeku A [1999]. Surveillance of construction worker injuries: Utility of trade specific analysis. Applied Occ Env Hyg *14*:458-469.

Lowery JT, Glazner JE, Borgerding J, Bondy J, Lezotte DC, Kreiss K [2000]. Analysis of construction injury burden by type of work. Am J Ind Med *37*:390-399.

McKernan JL, Piacitelli GM, Roegner KC, Delaney L, Boiano JM [2002]. Occupational exposures in seismic retrofitting operations. Appl Occup Environ Hyg *17*:75-81.

McKernan J [2000]. Development of a hazard surveillance methodology for residential construction. Appl Occup Environ Hyg *15*:890-895.

MCERF [2000]. Mechanical contracting foundation annual report. Mechanical Contracting Education & Research Foundation (MCERF). [http://www.mcerf.org/about_us/AR2000MCF.pdf]. Date accessed: April 17, 2007.

NIOSH [1974]. National occupational hazard survey volume I - survey manual. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 74-127.

NIOSH [1977a]. National occupational hazard survey volume II - data editing and data base development. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-213.

NIOSH [1977b]. National occupational hazard survey volume III - survey analysis and supplemental tables. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 78-114.

NIOSH [1988]. National occupational exposure survey volume I - field guidelines. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 88-106.

NIOSH [1989a]. National occupational exposure survey volume II - sampling methodology. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 89-102.

NIOSH [1989b]. National occupational exposure survey research volume III: analysis of management interview responses. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 89-103.

NIOSH [1995]. National program for occupational safety and health in construction at the National Institute for Occupational Safety and Health. External Review Materials.

NIOSH [2001]. Data from the bureau of labor statistics - worker health by industry and occupation. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 01-120.

NIOSH [2001]. Eye safety: Emergency response and disaster recovery. National Institute for Occupational Safety and Health. [http://www.cdc.gov/niosh/eyesafe.html]. Date accessed: April 2007.

Pollack E, Keimig DG [1987]. Counting injuries and illnesses in the workplace: Proposals for a better system. Washington, DC: National Academy Press.

Pollack ES, Ringen K [1993]. Risk of hospitalization for specific non-work-related conditions among laborers and their families. Am J Ind Med *23*:417-425.

Pratt SG, Kisner SM, Moore PM [1997]. Machinery-related fatalities in the construction industry. Am J Ind Med *32*(1):42-50.

Ringen K, Englund A, Welch L, Weeks J, Seegal J (eds.) [1995a]. Occupational medicine state-of-the-art reviews: Construction safety and health. Philadelphia: Hanley and Belfus.

Ringen K, Englund A, Seegal J [1995b]. Safety and health in the construction industry. In: Annual review of public health, ed. G. Ommen et al. Palo Alto *16*:165-188.

Ringen K, Englund A, Seegal J [1995c]. Construction workers. In: Barry S. Levy and David H. Wegman, eds. Occupational health: Recognizing and preventing work-related disease, 3rd edition, Little Brown and Co., 1995, 685-701.

Ringen K, Seegal J, Weeks J [1998]. Construction. Chapter 93 in Jeanne M. Stellman, ed. Encyclopedia of occupational health and safety, 4th Edition. Geneva: International Labour Office.

Robinson C, Petersen W, Sieber K, Palu S, Halperin WE [1996]. Mortality of carpenters' union members employed in U.S. construction or wood products industries, 1987-1990. Am J Ind Med *30*:674-694.

Robinson C, Burnett C, Lalich N, Brackbill R. [1989]. Selected leads from the 1984 occupational mortality surveillance data. Cincinnati, OH: Illness Effects Section, NIOSH, Cincinnati, Ohio.

Steenland K, Palu S [1999]. Cohort mortality study of 57,000 painters and other union members: A 15-year update. Occup Environ Med *56*:315-321.

Stern F, Schulte P, Sweeney MH, Fingerhut M, Vossenas P, Burkhardt G, Kornak MF [1995]. Proportionate mortality among construction laborers. Am J Ind Med *27*:485-509.

Stout-Wiegand N [1988]. Fatal occupational Injuries in US industries, 1984: comparison of two national surveillance systems. AJPH *78*(9):1215-1217.

Suruda A, Liu D, Egger M, Lillquist D [1999]. Fatal injuries in the United States construction industry involving cranes, 1984-1994. J Occup Environ Med *41*(12):1052-1058.

Wang E, Dement JM, Lipscomb H [1999]. Mortality among North Carolina construction workers, 1988-1994. App Occup Environ Hyg, *14*:45-58.

Welch LS, Hunting KL, Weeks JL [1999]. Fatal and non-fatal injuries from vessels under air pressure in construction. J Occ Env Med *41*:100-104.

Welch L, Dong X, Carre F, Ringen K [2007]. Is the decrease in injury and illness rates in construction due to changes in reporting? Int J Occup Environ Health, *13*:39-45.

Appendix 4.1 Outputs

Develop a Construction Data Center

Journal Articles

Butler RJ, Baldwin ML, Johnson WG [2006]. The effects of occupational injuries after returns to work: work absences and losses of on-the-job …- Journal of Risk and Insurance, 2006 - Blackwell Synergy

Dong X [2005]. Long working hours, work scheduling, and work-related injuries in construction. Scan J Work Env Health 31(5):329-335.

Dong X, Men R, Haile E [2005]. Work-related deaths and injuries/illnesses among the U.S. construction workers, 1992-2003. MD: The Center to Protect Workers' Rights, August 2005

Dong X, Men Y, Chowdhury R. Hu H, Gittleman J [2004]. Chapter 4. High-risk industries and occupations, construction trades. Worker Health Chartbook, NIOSH 2005, 240-260

Dong X, Entzel P, Men Y, Chowdhury R, Schneider S [2004]. Effects of safety and health training on work-related injuries among construction laborers. Am Occup Environ Med 46(12).

Dong X, Platner J [2004]. Occupational fatalities of Hispanic construction workers from 1992 to 2000. Am J Ind Med 45:45-54.

Grob H, Dong X [1999]. Ergonomics, a question of feasibility: hearing before the Subcommittee on Oversight - Page 189.

Grob H [1999]. Employment dispute resolution and worker rights in the changing workplace - Page 273, CHAPTER 9 Dispute Resolution in the Building and Construction Trades, by Adreienne E. Eaton, Jeffrey H. Keefe - 303 pages.

Grob H [1998]. Safety first: technology, labor and business in the building of american work safety 1870-1939. Monthly Labor Review, Vol. 121.

Grob H [1998]. Self-regulation and safety programs in construction, doctoral dissertation, (Notre Dame, 1998).

Platner J, Dong X [2002], Impacts of digital information networks on construction contractors & unions. J Labor Res 23(4):575-589.

Pollack ES, Chowdhury R [2001]. Trends in work-related death and injury rates among U.S. construction workers. 1992-98. MD: The Center to Protect Workers' Rights.

Pollack ES, Franklin GM, Fulton-Kehoe D, Chowdhury R [1998]. Risk of job-related injury among construction laborers with a diagnosis of substance abuse. J Occup Environ Med 40(6):573-577.

Pollack ES, Griffin M, Ringen K, Weeks JL [1996]. Fatalities in the construction industry in the United States, 1992 and 1993. Am J Ind Med 30(3):325-330.

Waehrer G, Dong X, Miller T, Haile E, Men Y (in press) [2007]. Costs of occupational injuries in the construction industry. Injury Prevention.

Welch LS, Dong X, Carre F, Platner J, Ringen K [2007]. Is the decease in injury and illness rates in construction due to changes in reporting? Int J Occ Env Health 13:39-45.

Conference Papers and Presentations

Dong X [2006]. The Construction Chart Book Updating. Construction Economic Research Network Meeting, Silver Spring, MD, June 6, 2006.

Dong X [2006]. The Construction Chart Book, the Fourth Edition Planning. Technical Advisory Board Meeting, San Francisco, CA, April 6, 2006.

Dong X [2006]. Health Services for Work-Related Injuries among Hispanic Construction Workers. American Public Health Association 134th Annual Meeting & Exposition, Boston, MA, November 7, 2006.

Dong X [2006]. Recent Safety and Health Trends among Hispanic Construction Workers. NIOSH Construction Safety and Health Research Consortium Meeting, Boston, MA, Nov 3, 2006.

Dong X [2006]. Medical Care, Expenses, and Sources of Payment for Work-Related Injuries among Construction Workers. Technical Advisory Board Meeting, Boston, MA, Nov 2, 2006.

Dong X [2006]. The Construction Chartbook Updating. Construction Economic Research Network Meeting, Silver Spring, MD, June 6, 2006.

Dong X [2006]. Health Services Utilization among Hispanic Construction Workers, the NORA 2006 Symposium, Washington DC, April 18, 2006.

Dong X [2006]. The Construction Chart Book, the Fourth Edition Planning. Technical Advisory Board Meeting, San Francisco, CA, April 6, 2006.

Dong X [2005]. Safety and Health in Residential Construction. Construction Economics Research Network Meeting, Silver Spring, MD, Nov 17, 2005.

Dong X [2005]. Safety and Health in Residential Construction. Construction Economics Research Network Meeting, Silver Spring, MD, Nov 17, 2005.

Dong X [2005]. Construction Safety and Health Surveillance & Injury and Illness Data. Bureau of Labor Statistics headquarters, Washington DC, August 2, 2005.

Dong X [2005]. Data Sources for Construction Safety and Health Research. National Academies. Washington DC, July 7, 2005.

Dong X [2005]. Safety and Health Surveillance in the Construction Industry. NIOSH Construction Safety and Health Research Consortium Meeting. Silver Spring, MD, April 6-7, 2005.

Dong X, Men Y [2004]. Health Insurance among Hispanic Construction Workers, NIOSH Steps to a Healthier U.S. Workforce Conference, Washington DC, October 26-28, 2004.

Dong X, Men Y, Chowdhury R, Schneider S [2004]. Training Effects on Work-Related Injuries among Construction Laborers. Chicago IL, February 15, 2004.

Dong X, Men Y, Chowdhury R, Schneider S [2003]. Training Effects on Work-Related Injuries among Construction Laborers. Chicago, IL, NIOSH NOIRS, Pittsburgh, PA, October 28-30, 2003.

Dong X [2003]. Characteristics of Work Scheduling and Work-Related Injuries in Construction. NIOSH NOIRA, Pittsburgh, PA, October 28-30, 2003.

Dong X, Platner J [2002]. Workplace Safety and Health of Hispanic Construction Workers. 130th APHA Annual Meeting & Exposition, Philadelphia, PA, November 9-13, 2002.

Dong X [2002]. CPWR Data Center: Recent Research in Construction Safety and Health, Economics Research Network Meeting. Silver Spring, MD, Oct. 24-25, 2002.

Dong X [2002]. Work Scheduling, Overtime, & Work-Related Injuries in Construction. 12th Annual Construction Safety & Health Conference & Exposition, Chicago, IL, May 21-23, 2002.

Dong X [2002]. Trends of Construction Workforce & Their Safety and Health Implications.12th Annual Construction Safety & Health Conference & Exposition, Chicago, IL, May 21-23, 2002.

Dong X [2002]. Work Schedule & Work-Related Injury in Construction. Economic Research Network, Silver Spring, MD, April 2002.

Dong X, Platner J, McCann M, Ellenberger D [2001]. Countering the High Rate of Construction-Related Deaths with Research & Training. 129th APHA Annual Meeting, Atlanta, GA, October 21-25, 2001.

Dong X [2001]. Trends of Construction Workforce, 1980-2000. 129th APHA Annual Meeting, Atlanta, GA, October 21-25, 2001.

Dong X [2001]. Impact of Changing Culture and Technology on the Construction Workforce. Transportation Research Board Annual Meeting, Washington DC, January 8, 2001.

Gittleman J, Dong X, Men Y [2005]. Analysis of Fatal Injuries in Construction. 15th Annual Construction Safety Conference, Chicago, IL, February 15-17, 2005.

Grob H, Dong X [1997]. Ergonomics and the economic payoff in the construction sector proceedings and transcripts from - managing ergonomics in the 1990s. http://www.ergoweb.com/resources/reference/manergo/grob.cfm.

Platner J, Dong X [2005]. New immigrants in the construction industry, Proceedings of the NIOSH Immigrant Worker Conference, Lowell MA, NIOSH 2005.

Weil D [2000]. Assessing osha performance: evidence from the construction industry. IRRA Proceedings, 2000 - ksg.harvard.edu

Evaluate Injury, Illness, and Mortality Patterns for Construction Trades and Tasks

Journal Articles

Anderson JTL, Hunting KL, Welch LS [2000]. Injury and employment patterns among Hispanic construction workers. J Occup Environ Med 42:176-186.

Beaumont JJ, Weiss NS. [1980]. Mortality of welders, shipfitters and other metal trades workers in boilermakers local No. 104, AFL-CIO. Am J Ind Med 112(6):775-786.

Goldenhar LM, Hecker S, Moir S, Rosecrance J [2003]. The “Goldilocks Model” of overtime in construction: Not too much, not too little, but just right. J Saf Res, 34:215-226.

Hunting KL, Welch LS, Mawudeku A [2001]. Injury surveillance in construction: eye injuries. Applied Occup Env Hyg 16:1-7.

Hunting KL, Welch LS, Anderson JA [2000]. Injury surveillance in construction – injuries to laborers. J Occup Env Med 42:898-905.

Hunting KH, Nessel-Stephens L, Sanford SM, Shesser R, Welch LS [1994]. Surveillance of construction worker injuries through an urban emergency department. J Occup Med 36:356-364.

Hunting KL, Welch LS, Cuccherini BA, Seiger LS [1994]. Musculoskeletal symptoms among electricians. Amer J Ind Med 25:149-63.

McCann M, Hunting KL, Murawski JTL, Chowdhury R, Welch LS [2003]. Causes of electrical deaths and injuries among construction workers. Amer J Ind Med 43:398-406.

Nessel-Stephens L, Welch LS, Weeks JS, Hunting KL, Cardenas-Amaya J [1995]. Carbon monoxide poisoning from use of gasoline powered power washers in an underground parking garage. MMWR, 44 (18):356-364.

Robinson CF, Stern F, Venable H, Frazier T, Burnett C, Lalich N, Sestito J, Halperin W, Fingerhut M, Fine L [1995]. The assessment of mortality in the construction industry in the United States, 1984-86. Am J Occup Med 28:49-70.

Robinson CF, Halperin WE, Alterman T, et al [1995]. Book Chapter: mortality patterns among United States construction workers. State of the Art Reviews in Occupational Medicine, Construction Safety and Health 10:269-283.

Robinson CF, Halperin WE, Alterman T, Braddee RW, Burnett CA, Fosbroke DE, Kisner SM, Lalich NR, Roscoe RJ, Seligman PJ, Sestito JP, Stern FB, Stout, NA [1995]. Mortality patterns among construction workers in the United States. Occ Med 10(2):269-283.

Robinson CF, Burnett CA [1994]. Mortality patterns of U.S. female construction workers by race, 1979-1990. J Occup Med 36(11):1228-1233.

Robinson CF, Venable H, Stern F, Burnett C, Sieber K, Sestito J, Frazier T, Fingerhut M [1992]. Occupational exposure and the mortality patterns of U.S. construction trades workers 1984-86: Filling in the Gaps. Revue D'Epidemiologie et de Sante Publique 40:142 (Suppl I).

Robinson CF, Venable H, Stern F, Burnett C, Sieber K, Sestito J, Frazier T, Fingerhut M [1992]. Expositions professionnelles et mortalite chez les travailleurs de la construction aux etats-unis en 1984-86: Combler les Vides. Archives des Maladies Professionnelles 53(6):601-602.

Robinson CF, Petersen M, Palu S [1999]. Mortality patterns among electrical workers exposed in the US construction industry 1982-87. Am J Ind Med 36:630-637.

Salg JA, Alterman T []. Mortality patterns among the international union of bricklayers and allied craftsmen (IUBAC) 1986-1991. Am J Epidemiol 145:(11) S51-51 Suppl.

Stern F, Lehman E, Ruder A [2001]. Mortality among unionized construction plasterers and cement masons. Am J Ind Med 39:373-388.

Stern F, Ruder AM, Chen G [2000]. Proportionate mortality among unionized roofers and waterproofers. Am J Ind Med 37:478-492.

Stern et al. [1997]. Proportionate mortality of among unionized construction ironworkers. Am J Ind Med 31:176-187.

Stern et al. [1997]. Proportionate mortality of among unionized construction operating engineers. Am J Ind Med 32:51-65.

Stern F, Sweeney MH [1997]. Proportionate mortality among construction operating engineers. Am J Ind Med 32:51-65.

Sweeney MH, Fosbroke, D, Goldenhar L, Jackson LL, Linch K, Lushniak BD, Merry C, Schneider, S, and Stephensen M [2000]. Health Consequences of Working in Construction in Coble RJ, Hinze J, and Haupt TC (eds): Construction Safety and Health Management; Prentice-Hall, NJ, p. 211-234.

Welch LS, Hunting KL, Murawski JA [2005]. Occupational Injuries Among Construction Workers Treated in a Major Metropolitan Emergency Department in the United States. Scan J Work Environ Health, 31 suppl 2:11-21

Welch LS, Hunting KL [2003]. Injury Surveillance in Construction: What Is an “Injury”, Anyway? Amer J Ind Med 44:191-196.

Welch LS, Goldenhar LM, Hunting KL [2000]. Women in construction: occupational health and working conditions. JAMWA 55:1-4.

Welch LS, Hunting KL, Nessel-Stephens L [1999]. Chronic symptoms in construction workers treated for musculoskeletal injuries. Amer J Ind Med 36:532-540.

Xiang H, Stallones L, Chen G, Smith GA [2005]. Work-Related Eye Injuries Treated in Hospital Emergency Departments in the US: AJIM 48:57-62.

NIOSH Publications

NIOSH [2000]. Health Hazard Evaluation Report: HETA 98-0308-2785, International Union of Bricklayers and Allied Craftworkers (IUBAC), Washington, D.C.

Schulte PA, Ahlers HW, Jackson LL, Malit BD, Votaw DM [2005]. Contact Lens Use in a Chemical Environment: Current Intelligence Bulletin 59; DHHS (NIOSH) Publication Number 2005-139.

Conference Papers and Presentations

Alterman [1997]. Mortality Patterns 1987-1990 in The International Brotherhood of Carpenters and Joiners of America - Illness and Injury Prevention for the Future. Presented to the United Brotherhood of Carpenters Annual Health and Safety Conference, Palm Springs, California, March 25, 1997.

Alterman [1997]. What's Killing Carpenters - Injury and Illness Prevention for the Future? A presentation and focus group discussions were held with Joe Durst, Director, Occupational Safety and Health, National Carpenters Union. Focus Groups presented to the United Brotherhood of Carpenters Annual Health, Safety and Apprenticeship Conference, Palm Springs, California, March 24-26, 1997.

Alterman T, Robinson C, Durst, J [1997]. What's Killing Carpenters? Injury and Illness Prevention for the Future. United Brotherhood of Carpenters and Joiners Health and Safety Conference. Two workshops given identifying injury and illness risks and prevention. Palm Springs, CA, March 1997.

Anderson JTL, Hunting KL, Welch LS [1999]. Non-fatal injuries among Hispanic construction workers. Presented at American Public Health Association, Indianapolis, November 1999.

Brown SE, Jackson L [1998]. Work-related eye injury--United States: American Public Health Association Meeting, Washington DC, November 15-19, 1998.

Brown S, Jackson L, Witherspoon D, Morris R [1998]. Work-related eye injury--United States. CDC Epidemiology Intelligence Service Annual Conference, Atlanta GA.

Fine L [1993]. Black and White Women U.S. Construction Workers' Mortality Patterns. Presented at: International Commission on Occupational Health, Nice, France, September 1993.

Goldenhar LM, Hecker S, Moir S, Rosecrance J [2002]. Developing a model of overtime in construction: Not too much, not too little, but just right. Construction Safety Conference. Chicago, IL. April 2002.

Goldenhar LM, Hecker S, Moir S, Rosecrance J [2002]. Developing a model of overtime in construction: Not too much, not too little, but just right. 8th Annual Qualitative Health Research Conference. Banff, Alberta Canada. April 4, 2002.

Hunting KL, Anderson JTL, Welch LS [2000]. Follow-up Study of Musculoskeletal Injuries Among Construction Workers. Presented at the International Ergonomic Association, San Diego, August 2000.

Hunting KL, Welch LS, Hsu L [2000]. Follow-up Study of Musculoskeletal Injuries Among Construction Workers. National Occupational Injury Research Symposium, Pittsburgh PA, November 2000.

Hunting KL, Anderson JTL, Welch LS [2000]. Injuries and Employment Patterns Among Hispanic Construction Workers. National Occupational Injury Research Symposium, Pittsburgh PA, November 2000.

Hunting KL, Welch LS, Anderson JTL, Mawudeku A [1998]. A follow-up study of falls among construction workers. Presented at American Public Health Association, Washington DC, November 1998.

Hunting KL, Welch LS, Anderson JTL, Mawudeku A [1998]. Use of emergency department records for construction injury surveillance. Presented at American Public Health Association, Washington DC, November 1998.

Hunting KL, Welch LS, Anderson JTL, Mawudeku A [1998]. A follow-up study of falls among construction workers. Presented at American Public Health Association, Washington DC, November 1998.

Hunting KL, Nessel-Stephens L, Welch LS [1997]. Validity of task assessment in sheet metal workers. Presented at the International Ergonomics Association/International Committee on Occupational Health, Tampere Finland, July 1997.

Hunting KH, Nessel-Stephens L, Sanford SM, Shesser R, Welch LS [1996]. Surveillance of construction worker injuries through an urban emergency department. Presented at the American Public Health Association, New York, NY, November 1996.

Hunting KL, Nessel-Stephens L, Welch LS [1996]. Longitudinal study of musculoskeletal injuries in construction workers. Presented at the American Public Health Association, New York, NY, November 1996.

Jackson LL, Boergerding JA, Lowery JT, Glazner JE [2000]. Eye injuries at a large construction project: a better understanding through compensation data and injury investigations: National Occupational Injury Research Symposium, October 17-19, 2000, Pittsburgh, PA, NOIRS 2000 Abstracts, p. 56.

Mawudeku A, Hunting KL, Welch LS, Anderson JTL. Follow-up study of eye injuries among construction workers. Presented at American Public Health Association, Indianapolis, November 1999.

Nessel-Stephens L, Welch LS, Hunting KL. Trade specific injury rates among construction workers. National Occupational Injury Research Symposium, Morgantown WV November 1997.

Robinson C and Burnett C [1993]. Black and White Women U.S. Construction Workers' Mortality Patterns. Presented at: Womens' Health: Occupation and Cancer Conference, Baltimore, Maryland, November 1993.

Robinson C and Burnett C [1993]. Black and White Women U.S. Construction Workers' Mortality Patterns. Presented at: American Public Health Association, San Francisco, California, October 1993.

Robinson C, et al. [1992]. Potential Exposures and the Occupational Mortality of Construction Workers 1984-86: Filling in the Gaps. U.S. P.H.S. Professional Association, Cincinnati, Ohio.

Robinson C, et al. [1992]. Potential Exposures and the Occupational Mortality of Construction Workers 1984-86: Filling in the Gaps. U.S. P.H.S. Professional Engineers Seminar, Cincinnati, Ohio.

Robinson C, et al. [1991]. Potential Exposures and the Occupational Mortality of Construction Workers 1984-86: Filling in the Gaps. Presented at: American Conference of Industrial Hygienists, Salt Lake City, Utah.

Robinson C, et al. [1991]. Potential Exposures and the Occupational Mortality of Construction Workers 1984-86: Filling in the Gaps. SER, Buffalo, New York.

Robinson C, et al. [1991]. Potential Exposures and the Occupational Mortality of Construction Workers 1984-86: Filling in the Gaps. National Conference on State-Based Occupational Health and Safety Activities, Cincinnati, Ohio.

Robinson C, et al. [1991]. Potential Exposures and the Occupational Mortality of Construction Workers 1984-86: Filling in the Gaps. Epidemiology in Occupational Health, International Commission of Occupational Health, Paris, France.

Robinson C, et al. [1991]. Potential Exposures and the Occupational Mortality of Construction Workers 1984-86: Filling in the Gaps. American College of Epidemiology, Atlanta, Georgia.

Stern [1999]. Proportionate mortality among construction plasterers and cement masons. American Public Health Association. Chicago, Illinois, 1999.

Stern [1998]. Proportionate mortality among construction roofers and waterproofers. American Public Health Association. Washington, D.C., 1998.

Stern F [1994]. Proportionate mortality among construction laborers. Tenth International Symposium. Epidemiology in Occupational Health. Como, Italy, 1994.

Stern [1994]. Proportionate mortality among construction laborers. American Public Health Association. Washington, D.C., 1994.

Walker F, Myers J, Geidenberger C [1997]. National estimates of eye injuries based on the Traumatic Injury Surveillance of Farmers Survey: National Occupational Injury Research Symposium '97, Morgantown, WV, Abstracts p. 27.

Welch LS, Hunting KL, Anderson JTL [2000]. Concrete form work, injury, and musculoskeletal disorders. Proceedings of the International Ergonomic Association, San Diego, August 2000.

Welch LS, Hunting KL, Anderson JTL [2000]. Concrete form work, injury, and musculoskeletal disorders. Presented at the International Ergonomic Association, San Diego, August 2000.

Welch LS, Hunting KL, Anderson JTL [1999]. Occupational injuries among laborers. Presented at American Public Health Association, Indianapolis, November 1999.

Welch LS, Hunting KL, Mendes M [1998]. Trade specific injury rates at a large construction project. Presented at American Public Health Association, Washington DC, November 1998.

Welch LS, Hunting KL, Nessel-Stephens L [1997]. Longitudinal study of musculoskeletal injuries in construction workers. Presented at the International Ergonomics Association/International Committee on Occupational Health, Tampere Finland, July 1997.

Welch LS [1994]. Use of a passive surveillance system for construction worker injury and illness. NIOSH Symposium on Efforts to Prevent Injury and Disease among Construction Workers, Cincinnati Ohio, July 1994.

Evaluate the Reliability of Existing Surveillance Systems used for Construction

Journal Articles

Dement JM, Lipscomb H, Li L, Epling C, Desai T [2003]. Nail Gun Injuries among Construction Workers. Appl Occup Environ Hyg 18(5):374-383.

Glazner JE, Borgerding J, Bondy J, Lowery J, Lezotte D, Kreiss K [1999]. Contractor safety practices and injury rates in construction of the Denver International Airport. Am J Ind Med 35:175-185.

Lipscomb HJ, Dement JM, Gaal J, Cameron W, McDougall V [2000]. Work related injuries in drywall installation. Appl Occup Environ Hyg 15(10):794-802.

Lipscomb HJ, Dement JM, Rodriguez-Acosta R [2000]. Deaths from external causes of injury among construction workers in North Carolina, 1988-1994. Appl Occup Environ Hyg 15(7):569-580.

Lowery JT, Borgerding J, Zhen B, Glazner JE, Bondy J, Kreiss K [1998]. Risk factors for injury among construction workers at Denver International airport. Am J Ind Med 34:113-120

Sorock G, Smith G, Reeve G, Dement J, Stout N, Layne L, Pastula T [1997]. Three Perspectives on Work-Related Injury Surveillance. Amer J Ind Med 32:116-128.

Wang E, Dement JM, Lipscomb HJ [1999]. Mortality among North Carolina Construction Workers: 1988-1994. App Occup Env Hyg 14:45-58.

NIOSH and CPWR Publications

eLCOSH – "Surveillance of Construction Workers", Final Report to The Center To Protect Workers' Rights CPWR/NIOSH Cooperative Agreement (CCU312014), January 2, 2001.

Conference Papers and Presentations

Bondy J, Glazner JE [2000]. The Concentration of Workers' Compensation Expenditures in a Construction Workforce: Implications for Cost Containment. National Occupational Injury Research Symposium 2000.

Glazner JE, Borgerding J, Bondy J, Lowery JT, Lezotte DC, Kreiss K [2000]. Contractor Safety Practices and Injury Rates During Construction of Denver International Airport. National Occupational Injury Research Symposium 2000.

Glazner JE, Borgerding JA, Lowery JT, Bondy J, Kreiss K [1997]. Construction Injury Rates May Exceed National Estimates: Evidence from the Construction of Denver International Airport (DIA), National Occupational Injury Research Symposium '97.

Kreiss K, Lowery J, Borgerding J, Zhen B, Glazner J [1996]. Risk Factors for Worker Injury in the Construction of Denver International Airport, Stockholm. International Conference on Occupational Health.

Lowery JT, Glazner JE, Borgerding JA, Bondy J, Lezotte DC, Kreiss K [2000]. Analysis of Construction Injury Burden by Type of Work. National Occupational Injury Research Symposium 2000.

Lowery JT, Borgerding JA, Zhen B, Glazner JE, Bondy J, Kreiss K [1997]. Risk Factors for Injury Among Construction Workers on the Denver International Airport (DIA) Project. National Occupational Injury Research Symposium ’97.

Dement [1994]. Health Effects of Asbestos in Construction, Conference on Ergonomics, Safety, and Health in Construction, Boston and Atlanta, 1994.

Dement [1997]. Workers’ Compensation Experience of N.C. Residential Construction Workers, NIOSH National Occupational Injury Research Symposium, Morgantown, WV, October 1997.

Dement [1999]. Surveillance of Injuries and Illness among Residential Construction Workers, National Building Trades National Conference, Washington, D.C., April 1999.

Lipscomb H, Dement J [2000]. Nail Gun Injuries in Construction: Need for Gun Control, NIOSH National Occupation Injury Research Symposium, Pittsburgh, PA, October 2000.

Dement [2001]. Nail Gun Injuries in Construction, National Safety Congress, Atlanta, GA, September, 2001.

Dement [2002]. Surveillance of Nail Guns in Construction, Construction Safety Conference, Construction Safety Council, Chicago, IL, May 22, 2002.

Sub goal 4.2 Address special populations of employers and employees within construction (e.g. immigrant workers, youth workers)

A) Introduction and History

The construction workforce includes several sub-populations with unique needs or disproportionate risks. The Construction Program tracks these developments and has targeted research to improve understanding of underlying factors and to develop targeted interventions. Sub-populations include Hispanic workers, immigrant workers, young workers, and women workers. Small employers and self-employed construction workers can also be viewed as sub-populations. Some additional details are provided below:

Construction has the second highest percentage of Hispanic workers outside of agriculture, accounting for 29.3% of the private sector construction production workforce [BLS 2006a]. Employment of Hispanic construction workers varies and is higher in Southwestern states and in certain trades. Work-related death rates for Hispanic construction workers are consistently 80% higher (in 2000, RR 1.84 95% C.I. 1.6-2.1) than that of their non-Hispanic counterparts [Dong and Platner 2004]. Hispanic construction workers are approximately one third native-born and two-thirds foreign-born workers. While unauthorized[6] immigrant workers represented 4.9% of the total civilian labor force, they represented 14% of the construction workforce. Hispanics constituted 66.5% of growth in the construction workforce in 2005-6. Four of the five detailed occupations with the highest share of immigrant workers are in construction and include: #1 - Insulation workers at 36%; #3 - Roofers at 29%; #4 - Drywall installers, ceiling tile installers, and tapers at 28%; and # 5 - Helpers, construction trades at 27% [Passel 2006].

Construction represents 3.7% of the youths aged15 to 17 years working [NIOSH 2006a] but 18% of young worker deaths: 10% of these were among youth less than 16 years of age [Windau and Meyer 2005].

While BLS data suggest that about 9.6% of the construction workforce is comprised of women employees, many are in construction management (7.8% in 2006) technical and support occupations, and only about 3.1% of production construction workers are women [BLS 2006a].

Construction Program and Center researchers have collaborated with the NIOSH Traumatic Injuries Program, the NIOSH Occupational Health Disparities Coordinated Emphasis Area, community and day labor organizations, and colleagues at state and federal level to explore and address some of these issues.

[6] The term “unauthorized” was used by the Pew Hispanic Center Research Report to describe undocumented immigrant workers

B) Approach

Hispanic and Immigrant workers

Protecting safety and health of Hispanic workers is a critical challenge facing the construction industry. Construction Program and Center researchers have conducted projects to: 1) examine the safety and health status of Hispanic construction workers; 2) identify disparities in safety and health and utilization of health services among Hispanic construction workers; 3) identify major socioeconomic and work organization factors contributing to the disparities and creating potential barriers to injury reducing interventions; and 4) develop intervention strategies to reduce/eliminate the disparities and improve safety and health of Hispanic construction workers overall.

The impact of language differences as a risk factor requires further evaluation, given the importance of communication to safety. In the construction industry, trainers (often foremen or supervisors) may not speak Spanish but must deliver training to mixed crews of workers. Crews often include workers who may not speak or read English as well as workers for whom English (or Spanish) is a second language. Informal coworker interpreters are often used for training, resulting in potentially serious gaps in the adequacy of task instructions and training. Potential risk factors include precarious employment, immigration status, economic security, cultural norms about safety and communication with authority figures, awareness of workplace rights, union membership, lack of OSHA coverage and enforcement among small employers or self-employed workers, lack of job experience, inadequate job skills and safety training, and low literacy levels.

To improve the effectiveness of occupational safety and health (OSH) training for recent (<2 years in U.S) foreign-born Hispanic workers, Construction Program and Center researchers are currently investigating unique aspects of safety culture and work practices. Research includes: 1) improving our understanding of differences in prior OSH knowledge, safety related work practices, risk perception, perceived manager expectations, time in the US, English proficiency, and evaluating their association with self reported lost work time injuries, 2) developing and evaluating the impact of culturally tailored OSH training modules in construction, and 3) evaluating the effectiveness of culturally tailored OSH training modules as compared to untailored OSH training modules.

The Construction Program and Center engaged participants in a workshop by the National Research Council to examine “Communicating Occupational Safety and Health to Spanish-speaking Workers and Employers” in 2002 which resulted in a National Academies Press report entitled “Safety Is Seguridad”. Both NIOSH and the Construction Center have actively developed and distributed Spanish language materials in both print and web forms. These are widely accessed from the US and Latin America. Description of the Spanish ELCOSH resources in Spanish are described in sub goal 4.5.

The Construction Program and Center are both collaborating with the NIOSH Communications Program, the Hollywood, Health and Society Project (a project with the University of Southern California Annenberg Norman Lear Center) and the Telemundo Network to develop an innovative pilot insertion of occupational safety information into a televised Spanish soap opera (telenovela). The collaboration is providing Telemundo with accurate factual information about construction worker safety, initially about prevention of falls in Hispanic construction workers. Telemundo’s writers and producers will incorporate this information into storylines for two telenovelas, public service announcements, and an associated web site as a means of communicating construction occupational safety and health information to a traditionally hard-to-reach audience.

Young Workers in Construction

There are a number of contributing factors to the high rates of young worker injuries including: inadequate abatement of recognized hazards in youth workplaces; absence of meaningful training for youth on the hazards in the work environment; inexperience of youth; physical, cognitive and emotional characteristics related to youth development; lack of appropriate supervision; and inappropriate work assignments that are illegal or otherwise exceed the capabilities of working youth [NRC 1998; Castillo et al. 1999].

The Construction Program collaborates with the Traumatic Injury Program to reduce young worker injuries. In response to the1998 National Research Council report, “Protecting Youth Workers” [NRC 1998] youth less than 18 years of age were added as a specific target for fatality investigations by the FACE program in 1999. To evaluate young workers in the construction industry, Construction Program and Center researchers have analyzed existing data to describe the magnitude and circumstances of young worker injuries; developed investigative guidelines for investigating young worker deaths, provided technical support and assistance to states with NIOSH cooperative agreements, reviewed the adequacy of existing child labor laws; and administered an extramural research program to provide empirical data to guide future rulemaking to protect young workers in construction. NIOSH recommended a new Hazardous Order to U.S. Department of Labor, which would limit all youth work on construction sites. U.S. Department of Labor issued an advanced notice of proposed rulemaking requesting comments on this recommendation in 2007.

The Construction Program supported a Request for Applications to fund extramural research projects focusing on health and safety hazards to youth working in the construction industry. A University of North Carolina project examined work patterns, practices, and injury experiences among young construction workers in North Carolina, with special emphasis on Latino workers [Runyan et al. 2006; O’Connor et al. 2005; Lipscomb and Li 2001]. The objective of the second project, at the University of Utah, was to calculate and compare fatality rates among young (< age 18) and older construction workers according to injury circumstances, establishment size, union affiliation, and employer gross income, using 15 years of OSHA investigation data and employment data [Suruda et al. 2003]. Partial funding was also provided for a third project at the University of Washington that was a prospective study of noise-induced hearing loss in newly hired construction workers [Seixas et al. 2005].

Women in Construction

Construction Program researchers examined the impact of a number of job stressors, including sexual harassment and gender-based discrimination, on female construction workers' level of job satisfaction and psychological and physical health. Major categories of concern were identified, including: (1) exposure to chemical and physical agents; (2) injuries from lifting/bending/twisting, falling, and lacerations; (3) lack of proper education and

training; and (4) the health and safety risks related specifically to tradeswomen. While some of the identified issues were associated with construction safety culture issues and discrimination, many were seen as amenable to change through engineering, organizational, or administrative interventions.

C) Outputs and Transfer

(See Appendix 4.2 for full list of outputs related to this sub goal topic)

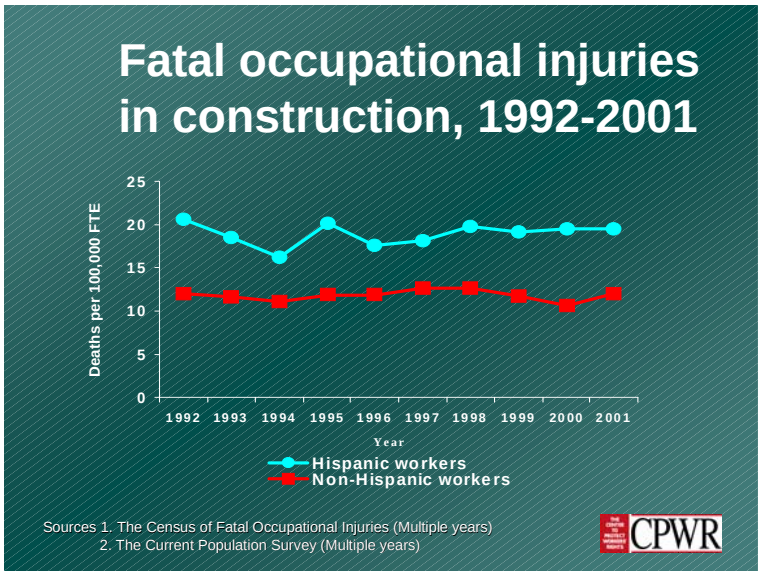
Construction Program and Center researchers authored a total of 25 peer reviewed journal articles on this topic, provided 13 presentations, and developed 19 NIOSH and Center publications.

Hispanic Workers in Construction
Researchers have presented or been invited to present these findings to a number of groups including the American Industrial Hygiene Association, American Public Health Association, Construction Safety Council, Hispanic Forum of the National Safety Council, International Social Security Association Construction Section, Pan American Health Organization World Health Day, NIOSH NORA Conferences, Building and Construction Trades Department AFL-CIO Safety Committee, among others.

Researchers were requested to present findings on Hispanic construction fatalities at a hearing of the House of Representatives Committee on Education and Labor, Workforce Protections Subcommittee.

Construction Program staff attended the Border Health Conference in Mexico (FY04) to discuss NIOSH outreach activities and to disseminate NIOSH Spanish-language documents.

Construction Program staff were interviewed by the National Public Radio and invited by congressional representatives for a discussion of issues related to Hispanic safety and health. Staff efforts helped identify the NIOSH research priorities and contributed to the OSHA safety and health legislations on Hispanic workers.



The Construction Center article on Hispanic fatalities in construction was translated into Spanish and presented at the Annual National Conference of Mexican Institute of Social Security in 2004 [Dong and Platner 2004].

In FY 04, Construction Program staff participated on the OSHA Hispanic Task Force and the NACOSH Summit of Occupational Safety and Health Issues of Immigrant Workers.

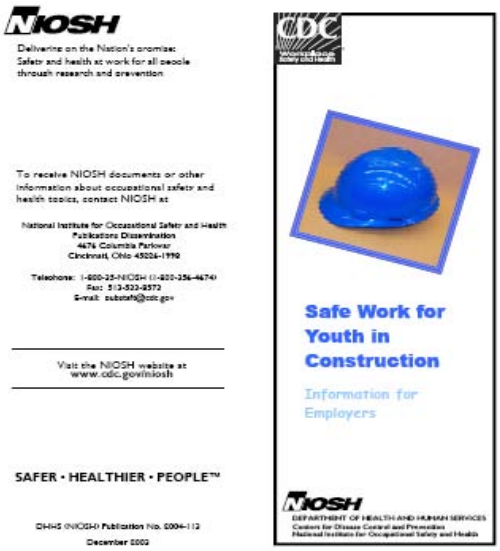
The Construction Center participated in a workshop sponsored by the National Research Council of the National Academy of Sciences concerning communicating occupational safety and health information to Spanish-speaking workers and employers. The Program supported NAS report (Safety is Seguridad) was received in March 2003 and disseminated to key stakeholders, study participants, and other interested parties [NRC 2003].

Spanish language documents on the Electronic Library of Occupational Safety and Health (http://www.elcosh.org/espanol) constitute as much as 40% of web traffic in some months, which represents approximately 750,000 hits per year. Since 2000, the Center distributed approximately 36,300 Hazard Alert cards in Spanish at the request of safety representatives and trainers.

With a day laborer community organization in New Jersey, and Rutgers University a basic construction safety program was adapted using participatory research methods , delivered with worker trainers, and follow-up interviews demonstrated self-reported changes in safe work practices and improved knowledge.

Young Workers in Construction

The pamphlet *Safe Work for Youth in Construction (Information for Employers*) was developed by Construction Program researchers and in May 2004, 8,000 packets on young worker safety and construction work were sent to approximately 8,000 small construction contractors. The mailing included a cover letter signed by agency heads from NIOSH, the DOL Wage and Hour Division (WHD - responsible for federal child labor laws) and OSHA; the NIOSH pamphlet *Safe Work for Youth in Construction (Information for Employers)* (16,778 copies distributed), and publications from the Wage and Hour Division and OSHA [NIOSH 2003b]. All NIOSH documents focusing on young worker injuries are included on a NIOSH “Young Worker Safety and Health” web site (www.cdc.gov/niosh/topics/youth/).



Since 1999 when NIOSH added youth as a specific target for fatality investigations, NIOSH Program staff conducted nine FACE investigations of young construction worker deaths, and states with FACE cooperative agreements have conducted three young construction worker fatality investigations. These reports are posted on the NIOSH Web site at: http://www.cdc.gov/niosh/injury/traumaconstructface.html and copies are provided to WHD and OSHA. State FACE programs disseminate reports within their own states, and frequently provide copies to state child labor regulatory agencies.

A project team consisting of Construction and Traumatic Injuries staff provided the Department of Labor Employment Standards Administration (ESA) and Wage and Hour Division (WHD) with science-based recommendations for revisions to federal child labor laws by submitting NIOSH comments in response to public comment periods on proposed rule changes, and a comprehensive 2002 NIOSH report developed through a NIOSH/ESA interagency agreement [NIOSH 2000]. Construction Program staff made recommendations for revisions to several existing Hazardous Orders with relevance to the construction industry, including roofing and excavation occupations, and recommended several new hazardous orders, including a Hazardous Order for construction occupations [Castillo et al. 2002]. The 2002 comprehensive report was posted on the NIOSH Web site and provided to requestors such as the Child Labor Coalition and International Labour Organization. Construction Program researchers also participated in stakeholder meetings organized by ESA/WHD to seek input on the scope and prioritization of NIOSH recommendations.

Women in Construction

Construction Program researchers authored a NIOSH document, “Providing Safety and Health Protection for a Diverse Construction Workforce: Issues and Ideas” [NIOSH 1999] with 25,200 copies distributed. Research resulted in a peer-reviewed journal article: “Tradeswomen's Perspectives on Occupational Health and Safety: A Qualitative Investigation." and a presentation titled: “Effects of On-the-Job Harassment: Outcomes for Women Construction Workers. Preliminary Survey Findings” which was presented at a conference on Women’s Health.

D) Intermediate and End Outcomes

Hispanic Workers in Construction

Construction Center research findings on Hispanic construction workers have been frequently requested and cited by labor unions (e.g., Department of Occupational Safety and Health, AFL-CIO; the Building and Construction Trades Department (BCTD), Florida Building and Construction Trades); insurance companies (e.g., Liberty Mutual, Risk & Insurance); researchers (e.g., Bureau of Economic Analysis, Research Services Group, FMI Corporation, University of Minnesota), reporters (e.g., Seattle Times, NEA Safety Spotlight) and Hispanic organizations in their conferences, publications, and websites. For example, *El Constructor Latino*, the southeast’s premier bilingual construction publication for the Latino community used Construction Center data on Hispanic employment and business owners in the construction industry on their web www.elconstructorlatino.com.

Young Workers in Construction

A final rule published by the Department of Labor (DOL) in 2004 incorporated NIOSH recommendations in response to a public comment period on the proposed rule and a report that NIOSH developed at the request of DOL recommending changes to Hazardous Orders [69 Fed. Reg. 75382 (2004)].

NIOSH research and recommendations were cited among the justifications for the rule changes.

Since the release of the NIOSH Hazardous Orders recommendations in May 2002, numerous researchers, standards-setting bodies, legislators, and advocacy groups nationally and internationally have called for implementation of its recommendations or cited them as justification for the need to update child labor laws. One example is proposed legislation that references the NIOSH Hazardous Orders recommendations. In 2003 and again in 2005, Representative Tom Lantos (D-California) introduced the Youth Worker Protection Act, which would amend the Fair Labor Standards Act of 1938 (FLSA) to revise requirements relating to child labor and to set forth new requirements for the employment of minors. The Act included a provision directing the Secretary of Labor to promulgate a rule relating to particularly hazardous occupations for children between the ages of 16 and 18, specifying that this rulemaking was justified based on the Hazardous Orders recommendations released by the National Institute for Occupational Safety and Health in 2002 [GovTrack.us 2006a,b].

The NIOSH Alert on young worker safety has been repeatedly reprinted based on requests for more copies, and statistics on young worker deaths and injuries included in NIOSH publications are routinely cited in the press.

A number of organizations have referenced Construction research and data concerning young workers. In 2001, the American Public Health Association (APHA) issued policy statement 2001-9, “Protection of Child and Adolescent Workers,” that referenced NIOSH research [APHA 2002]. In a recent announcement by the Michigan Occupational Safety and Health Administration (MIOSHA) of a multi-year campaign focusing on youth worker safety and health, the MIOSHA acting director cited statistics reported in NIOSH publications, and made the following statement, “So when we saw these statistics we thought we should step up efforts to get information out to young people as they start their working careers [BNA 2006]. MI OSHA program materials make specific references to NIOSH statistics and the Michigan FACE program [MDLEG 2006].

In March 2003, the Young Worker Health and Safety Network (YWH&S) released its report, *NIOSH Recommendations for Changes to the Federal Child Labor Regulations: A Response from Members of the Young Worker Health and Safety Network.* The network is a subcommittee of the Occupational Health and Safety section of the American Public Health Association, comprised of public health professionals, advocates, educators, and government agency staff. More than 25 individuals from a variety of disciplines collaborated to develop the network’s response to the NIOSH Hazardous Orders recommendations [YWHS 2003].

The YWH&S Network agreed with the NIOSH recommendations pertaining to the existing Hazardous Orders (HOs) and identified Hazardous Order 16 on Roofing

as one of several top priorities for regulatory action along with several agricultural Hazardous Orders. The YWH&S Network comments were also the topic of a peer-review journal article, which further encouraged implementation of the NIOSH recommendations by DOL/ESA [Miller and Bush 2004].

In 2005, the Child Labor Coalition (CLC) prepared a report entitled *Protecting Working Children in the United States: Is the Government's Indifference to the Safety and Health of Working Children Violating an International Treaty?* [CLC 2005]. The CLC is a group of non-governmental organizations whose mission is to end child labor exploitation in the U.S. and abroad and to protect the health, education, and safety of working minors. The CLC report was submitted in June 2005 to the ILO Committee of Experts, which is an independent body charged with examining the application of ILO conventions in member states. In the report, the CLC questions whether the U.S. is in compliance with ILO Convention No. 182 (Elimination of the Worst Forms of Child Labour), with particular emphasis on Hazardous Orders and children working in agriculture. Data and rationale from the NIOSH Hazardous Orders report are used as the primary justification for changes. The report urges DOL/ESA to take action on NIOSH recommendations, particularly those which focus on the agricultural HOs.

World Health Organization and International Labour Organization who held an expert meeting on the development of guidelines for defining hazardous child labor. The NIOSH recommendations for changes to Hazardous Orders were put forward as one approach.

Women in Construction

NIOSH Construction Program researchers participated on Health and Safety of Women in Construction (HASWIC) workgroup, established by OSHA's Advisory Committee on Construction Safety & Health (ACCSH). The Workgroup prepared a report titled: "Women in the Construction Workplace: Providing Equitable Safety and Health Protection" http://www.osha.gov/doc/accsh/haswicformal.html. The two Construction Program research reports provided much information for the report. The full ACCSH adopted the report on March 13, 1997. The report, also available via eLCOSH, reported concerns such as the prevalence of a hostile workplace, restricted access to sanitary facilities, protective clothing and equipment in the wrong sizes, and poor on-the-job training that adversely impacted women's ability to perform their jobs safely.

E) External Factors

Hispanic Workers in Construction

The relative contributions of various external factors are difficult to characterize because of the rate of change as the number of foreign-born Hispanics working in construction grows rapidly. In some regions, it is increasingly necessary to be bilingual in order to function in the construction industry. However, cultural and language barriers remain as important issues to consider in development of

injury and illness prevention interventions. Other factors include literacy levels (in English and Spanish), immigration status, immigration laws and ongoing reform debates, employer exploitation including non-payment of wages, misclassification as self-employed subcontractors (in which case labor laws including OSHA does not apply), and failure to correct unsafe work practices. Lack of health insurance coverage and lack of coverage and understanding of the state workers' compensation systems is a barrier to claims and reporting. Informal sector workers are frequently paid cash without formal employment relationships. It is the informal nature of these relationships that are likely to be attractive to undocumented workers, and provide a low threshold for initial employment of new immigrants. There are also important surveillance issues with a transient Spanish speaking workforce including exclusion of workers without landline telephones from CPS and many household national surveys, failure to collect ethnicity data or country of origin in many datasets, among others.

Young Workers in Construction

Most youth employment in construction already violates state or federal child labor laws, so workers under 18 may misrepresent their ages, which makes research challenging.

The scope of the NIOSH recommendations on changes to Hazardous Orders was delineated in interagency agreements between NIOSH and DOL/ESA in fiscal years 1999, 2000, and 2001. However, as the NIOSH report neared completion, the change in Administration in January 2001 led to changes in leadership at DOL and at DOL/ESA. New leadership had no investment in the NIOSH report, reacting somewhat defensively to the efforts of NIOSH and other stakeholders to promote it as an important tool for guiding future rulemaking.

In general, regulatory actions by DOL agencies have become increasingly difficult to initiate, as Federal agencies that wish to propose new rules are now required to evaluate the economic impact of these proposals. It is possible that the increased complexity of the rulemaking process has contributed to delays by DOL/ESA, which in 2007 has re-released for additional comment an advanced notice of proposed rulemaking related to the construction HOs for young workers.

In addition to external factors influencing rulemaking, there are a number of external factors that also impede progress in reducing young worker injuries. These include: lack of resources for focused and widespread intervention efforts, limited enforcement of child labor laws at the federal and state level, and an absence of specific OSHA standards that address hazards resulting in large numbers of nonfatal youth work injuries (e.g. lacerations, sprains and strains, and burns).

Women in Construction

Small percentage of women doing production work in construction represents an obstacle to improvement on issues of concern. A circular effect is created since

construction safety, health, and cultural issues create barriers to women entering and remaining in construction. In turn, the small numbers of women workers on construction worksites foster an environment in which these safety, health and cultural problems arise or continue. There has been an increase in organizations focusing on women in construction. The Building and Construction Trades Department created a “Women in the Trades Committee” in January of 2007, and the Department of Labor initiated a grant program in 2007 to help women enter apprenticeship programs.

F) What’s Ahead?

The NORA Construction Sector Council identified “Vulnerable workers” as a top issue for construction and is in the process of developing strategic and intermediate goals to address this topic area. This is expected to provide opportunities for looking systematically at needs of a variety of construction sub-populations. Additional details are as follows:

Hispanic Workers in Construction
The Construction Program has ambitious plans for future research into Hispanic workers in the construction industry. Some of the proposed immigration law reforms are likely to significantly change external factors effecting both surveillance and interventions targeting these populations. Two new journal articles have been completed and submitted to peer-review journals, while another article is being finalized. Research findings will be included in the fourth edition of The Construction Chartbook: The Construction Industry and Its Workers, to be published in October 2007.

A collection of case studies was developed describing initiatives to engage immigrant construction workers based on a working group of 128 activists in California (2007) and more than 50 telephone interviews of trainers and organizations nationally conducted by UC Berkeley LOHP. These will be disseminated nationally to construction safety trainers in 2007-8, and follow up surveys will evaluate implementation and barriers.

Research on safety practices, self-reported lost work time injuries and the impact of safety training is being evaluated among day laborers in northern New Jersey and an analysis of extensive live interviews of 400 Spanish speaking recent immigrant construction workers in Miami-Dade County, which are submitted for publication. These provide an improved base of qualitative information for guiding development of new interventions targeting these populations.

Construction staff recognizes the importance of establishing a construction information dissemination strategy with an emphasis on Spanish speakers. Planned projects include:

- Develop and print the proceedings of the NACOSH Summit during FY 07.

- Develop easy to read and pictorial documents in Spanish related to safety in construction work, beginning with documents about silicosis and the hazards of skylight openings.
- Establish partnerships with employers of Spanish-speaking workers to measure the impact of NIOSH material.
- Re-design Spanish Web sites to be more in line with user's needs.
- Collect input from customers at National Safety Council Hispanic Forum and others.
- Work with the Division of Safety Research to develop easy-to-read material based on NIOSH Alerts and Workplace Solutions dealing with construction.
- Develop topic concept plan for creating easy-to-read and pictorial documents in Spanish.
- Establish partnerships with employers and leaders of unions and safety organizations to make them aware of Construction Program Spanish materials.

Construction Program researchers will evaluate safety training for Spanish speaking roadway workers. This study will use a convenience sample provided by the Laborers' Health and Safety Fund of North America and their associated contractors who are involved in road and bridge construction. Supervisors of Spanish only (non-English) speaking workers will be recruited to participate in focus groups or in-depth-interviews. The findings from this study will be used to formulate a Roadway Safety Training Program for Spanish speaking workers.

The planned intermediate use of the study findings is to provide insights about these supervisors' perceptions, opinions, behaviors, and attitudes that can be used to evaluate the Laborers' Roadway Safety Training materials for Spanish speaking workers. It is anticipated that intermediate outcomes may include recommendations regarding the effectiveness of safety training materials that were designed to meet the learning needs of Spanish speaking construction workers.

- A measurable reduction in fatal and non-fatal injuries among Hispanic (Spanish speaking) construction roadway workers.
- Increased awareness in the training needs of Spanish speaking workers.

Additional activities are planned for the Telenovela project. To supplement the storyline, a PSA will be filmed with the show's main character and a construction safety website will be posted. The website, called Mi Trabajo Seguro, will be advertised through Telemundo's website (http://tv.telemundo.yahoo.com/index.html) and in the PSA announcement. The PSA will be aired at least 10 times while the show is on the air.
We will also be collaborating with Hollywood, Health and Society Project and a researcher at the University of Georgia to evaluate the impact and effects of this initiative on viewer's construction safety knowledge.

Young Workers in Construction

NIOSH is not currently actively engaged in efforts to encourage legislative or regulatory change to improve young worker safety. The 2002 NIOSH report recommending changes to federal child labor laws was comprehensive and should serve as a resource for years to come. Because recent FACE investigations of young worker deaths are less frequently identifying new prevention strategies, including recommendations for new or revised child labor laws, NIOSH is considering scaling back or removing youth as a target for FACE investigations. NIOSH will develop a report summarizing findings from FACE investigations of youth, with an emphasis on gaps identified in existing child labor laws.

NIOSH will continue to analyze existing data on young worker injuries and deaths, and report on data trends. NIOSH researchers will continue to provide technical support to the ESA/WHD, including responding to requests for technical information and sharing new scientific findings from NIOSH cooperative agreements and grants. NIOSH will develop and submit comments on future proposed rulemaking by the Department of Labor.

References

69 Fed. Reg. 75382 [2004]. Employment Standards Administration: child labor regulations, orders and statements of interpretation; child labor violations—civil money penalties; final rule.

APHA [2002]. 2001-9 Protection of child and adolescent workers. American Public Health Association. Am J Public Health *92*(3):461-462.

BLS [2006a]. Household data annual averages: Table 11. Employed persons by detailed occupation, sex, race, and Hispanic or Latino ethnicity. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics. Table available at ftp://ftp.bls.gov/pub/specialreports/lf/aat11.txt

BLS [2006b]. Household data annual averages: Table 3. Employment status of the civilian noninstitutional population by age, sex and race. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics. Table available at http://www.bls.gov/cps/cpsaat3.pdf

BNA [2006]. MIOSHA announces multi-year campaign focusing on youth worker safety, health. Occupational Safety & Health Reporter *36*(40):902-903, October 12, 2006.

Castillo DN, Davis L, Wegman DH [1999]. Young Workers. Occ Med: State of the Art Reviews *14*(3):519-536.

Castillo DN, Pratt SG, Mardis AL, Hendricks KJ [2002]. National Institute for Occupational Safety and Health (NIOSH) recommendations to the U.S. Department of Labor for changes to Hazardous Orders. Report to the U.S Department of Labor, Employment Standards Administration, Wage and Hour Division. May 3, 2002.

CLC [2005]. Protecting working children in the United States: Is the government's indifference to the safety and health of working children violating an international treaty? Washington, DC: Child Labor Coalition. http://www.stopchildlabor.org/pressroom/clc%20report.pdf. Date accessed: July 18, 2006.

Dong X, Platner J [2004]. Occupational fatalities of hispanic construction workers from 1992 to 2000 Am J Ind Med *45*:45-54.

GovTrack.us [2006a]. 108th Congress, 1st session. H.R. 3139: To amend the Fair Labor Standards Act of 1938 to reform the provisions relating to child labor, and for other purposes. http://www.govtrack.us/data/us/bills.text/108/h3139.pdf. Date accessed: July 19, 2006.

GovTrack.us [2006b]. 109th Congress, 1st session. H.R. 2870: To amend the Fair Labor Standards Act of 1938 to reform the provisions relating to child labor, and for other purposes. http://www.govtrack.us/data/us/bills.text/109/h2870.pdf. Date accessed: July 19, 2006.

Lipscomb HJ, L Li [2001]. Injuries among teens employed in the homebuilding industry in North Carolina. Inj Prev *7*:205-209.

MDLEG [2006]. Young worker initiative. Michigan Department of Labor & Economic Growth Available at: http://www.michigan.gov/cis/0,1607,7-154-11407-149772--,00.html

Miller ME, Bush D [2004]. Review of the federal child labor regulations: updating hazardous and prohibited occupations. Am J Ind Med *45*:218-221.

NIOSH [1999]. Providing safety and health protection for a diverse construction workforce: Issues and ideas. NIOSH Publication No. 99-140.

NIOSH [2000]. Comments of the National Institute for Occupational Safety and Health on the Department of Labor Notice of Proposed Rulemaking and Request for Comments on Child Labor Regulations, Orders and Statements of Interpretation; Child Labor Violations – Civil Money Penalties, 29 CFR Parts 570 and 579. January 28, 2000.

NIOSH [2003]. Safe work for youth in construction - information for employers. Cincinnati, OH: Department of Health and Human Services, Centers for Disease

Control and Prevention, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 2004-113.

NIOSH [2004]. Prevención de caídas de trabajadores por tragaluces y aberturas de techos y pisos. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2004-156 (Sp2005).

NIOSH [2006a]. Unpublished NIOSH analyses of the Current Population Survey. Morgantown, WV: National Institute for Occupational Safety and Health, Division of Safety Research, Injury Surveillance Team.

NRC [1998]. Protecting youth at work: health, safety, and development of working children and adolescents in the United States, National Research Council/Institute of Medicine. Washington, DC: National Academy Press.

NRC [2003]. Safety is Seguridad: A Workshop Summary. Board on Earth Sciences and Resources, National Research Council. Washington D.C.: National Academies Press.

O'Connor T, Loomis D, Runyan C, Abboud dal Santo J, Schulman M [2005]. Adequacy of health and safety training among young Latino construction workers. J Occup Environ Med *47*:272-277.

Passel J [2006]. The Size and Characteristics of the Unauthorized Migrant Population in the U.S., Estimates Based on the March 2005 Current Population Survey. Pew Hispanic Center. March 7, 2006. http://pewhispanic.org/files/reports/61.pdf.

Runyan CW, Santo JD, Schulman M, Lipscomb JH, Harris TA [2006]. Work hazards and workplace safety violations experienced by adolescent construction workers. Arch Ped Adol Med *160*(7):721-727.

Seixas NS, Goldman B, Sheppard L, Neitzel R, Norton S, Kujawa SG [2005]. Prospective noise induced changes to hearing among construction industry apprentices. Occ Env Med *62*:309-317.

Suruda A, Philips P, Lillquist D, Sesek R [2003]. Fatal injuries to teenage construction workers in the U.S. Am J Ind Med *44*:510-514.

Windau and Meyer [2005]. Occupational injuries among young workers. Monthly Labor Review *128*(10):11-23.

YWHS [2003]. NIOSH Recommendations for Changes to the Federal Child Labor Regulations: A Response from Members of the Young Worker Health and Safety Network. Youth Worker Health and Safety Network.

Appendix 4.2 Outputs

Hispanic Workers in Construction

Journal Articles

Dong X, Men Y, Ringen K (in press) [2007]. Nonfatal Work-Related Injuries among Hispanic Construction Workers: Evidence from the Medical Expenditure Panel Survey, American Journal of Industrial Medicine.

Dong X, Men Y, Haile E (in press) [2007]. The Uninsured among Hispanic Construction Workers, Journal of Health Care for the Poor and Underserved.

Welch LS, Dong X, Carre F, Platner J, Ringen K [2007]. Is the Decease in Injury and Illness Rates in Construction due to Changes in Reporting? Int J Occ Env Health 13:39-45.

Dong X, Men R, Haile E [2005]. Work-Related Deaths and Injuries/Illnesses among the U.S. Construction Workers, 1992-2003. MD: The Center to Protect Workers' Rights, August 2005.

Platner J, Dong X [2005]. New Immigrants in the Construction Industry, Proceedings of the NIOSH Immigrant Worker Conference, Lowell MA, NIOSH 2005.

Dong X, Men Y, Chowdhury R. Hu H, Gittleman J [2005]. Chapter 4. High-Risk Industries and Occupations, Construction Trades, Worker Health Chartbook, 2004, NIOSH 2005, 240-260.

NIOSH Publications

NIOSH [2004]. Prevención de caídas de trabajadores por tragaluces y aberturas de techos y pisos. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2004-156(Sp2005).

Conference Papers and Presentations

Dong X [2007]. Medical Expenditures for Work-Related Injuries among Hispanic Construction Workers. The 17th Construction Safety Conference, Rosemont, IL, February 13-15, 2007.

Dong X [2006]. Health Services for Work-Related Injuries among Hispanic Construction Workers. American Public Health Association 134th Annual Meeting & Exposition, Boston, MA, November 7, 2006.

Dong X [2006]. Recent Safety and Health Trends among Hispanic Construction Workers. NIOSH Construction Safety and Health Research Consortium Meeting, Boston, MA, Nov 3, 2006.

Dong X [2006]. Medical Care, Expenses, and Sources of Payment for Work-Related Injuries among Construction Workers. Technical Advisory Board Meeting, Boston, MA, Nov 2, 2006.

Dong X [2006]. Health Services Utilization among Hispanic Construction Workers, the NORA 2006 Symposium, Washington DC, April 18, 2006.

Dong X, Men Y [2004]. Health Insurance among Hispanic Construction Workers, NIOSH Steps to a Healthier U.S. Workforce Conference, Washington DC, October 26-28, 2004.

Dong X, Platner J [2002]. Workplace Safety and Health of Hispanic Construction Workers. 130th APHA Annual Meeting & Exposition, Philadelphia, PA, November 9-13, 2002.

7th IUHPE European Conference on Health Promotion and Health Education Budapest, Hungary, 18-21 October 2006.

7th Full Conference of the European Academy of Occupational Health Psychology Dublin, Ireland, 8-10 November 2006.

Young Workers in Construction

Journal Articles

Higgins DN, Tierney J, Lins M, Hanrahan L [2004]. School Nurses: A Resource for Young Worker Safety, J Sch Nur 20(6):317-323.

Higgins DN, Tierney J, Lins M, Hanrahan L [2004]. School nurses: a resource for young worker safety, J School Nursing 20(6):10-16.

Higgins D, Tierney J, Hanrahan L [2002]. Preventing youth worker fatalities: the Fatality Assessment and Control Evaluation (FACE) Program. AAOHN 50(11):508-514.

Davis L, Castillo DN, Wegman DH [2000]. Child and Adolescent Workers. In, Levy B, Wegman D (Eds), Occupational Health: Recognizing and Preventing Work-Related Disease, 4th Edition.

Castillo DN, Davis L, Wegman DH [1999]. Young workers. Occupational Medicine: State of the Art Reviews 14(3):519-536. (13 citations)

Castillo DN [1998]. Occupational Safety and Health in Young People. Barling J, Kelloway K (Eds), Young Workers: Varieties of Experience. Washington, D.C.: American Psychological Association, pp: 254-309.

Castillo DN, Malit BD [1997]. Occupational injury deaths of 16 and 17 year olds in the US: trends and comparisons with older workers. Injury Prevention 3(4):227-281.

CDC [1996]. Work-related injuries and illnesses associated with child labor--United States, 1993. MMWR 45(22):464-468.

NIOSH Publications

NIOSH [2004]. Worker Health Chartbook, 2004. NIOSH Publication No. 2004-146 (Special Populations: Young Workers Section, pp 266-276.)

NIOSH [2004]. Sixteen-Year-Old Hispanic Youth Dies After Falling From A Job-Made Elevated Work Platform During Construction—South Carolina. Morgantown, WV: Fatality Assessment and Control Evaluation (FACE) report no. 2004-06.

NIOSH [2004]. Two Hispanic Construction Laborers (Ages Fifteen and Sixteen) Die After Trench Collapse—South Carolina. Morgantown, WV: Fatality Assessment and Control Evaluation (FACE) report no. 2003-07.

NIOSH [2003a]. NIOSH Alert: Preventing deaths, injuries, and illnesses of young workers. Cincinnati, OH: Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS (NIOSH) Pub. No. 2003-128.

NIOSH [2002]. Seventeen-Year-Old Part-Time Road Construction Laborer Dies After Being Run Over by a Water Truck—Indiana. Morgantown, WV: Fatality Assessment and Control Evaluation (FACE) report no. 2001-10.

NIOSH [2002]. Fourteen-year-old laborer dies after falling through a skylight - Alabama. Morgantown, WV: Fatality Assessment and Control Evaluation (FACE) report no. 2001-07.

NIOSH [2002]. A 16-year-old roofer helper dies after 28-foot fall down an unguarded elevator shaft opening - Pennsylvania. Morgantown, WV: Fatality Assessment and Control Evaluation (FACE) report no. 2000-23.

NIOSH [2001]. A sixteen-year-old male died after falling 27 feet at a residential construction site - Alabama. Morgantown, WV: Fatality Assessment and Control Evaluation (FACE) report no. 2000-16.

NIOSH [2000]. Three tower painters die after falling 1,200 feet when riding hoist line - North Carolina. Morgantown, WV: Fatality Assessment and Control Evaluation (FACE) report no. 2000-07.

NIOSH [2000]. Youth laborer dies in trench collapse - Michigan. Morgantown, WV: Fatality Assessment and Control Evaluation (FACE) report no. 2000-03.

NIOSH [1999]. Youth dies in trench collapse - Arizona. Morgantown, WV: Fatality Assessment and Control Evaluation (FACE) report no. 99-02.

NIOSH [1997]. Child labor research needs: Recommendations from the NIOSH child labor working team. NIOSH Publication No. 97-143.

Women in Construction

Journal Articles

Goldenhar L, Welch L, Hunting KL [2000]. Women working in construction: risks and rewards. Safe Workplace. Aug-Sept: 1-2.

Welch LS, Goldenhar LM, Hunting KL [2000]. Women in construction**:** occupational health and working conditions. J Am Med Women's Assoc 55(2):89-92.

Goldenhar LM, Swanson NG, Hurrell JJ, Ruder A, Deddens J [1998]. Stressors and adverse outcomes for female construction workers. J Occup Health Psychol 3(1):19-32.

Goldenhar LM, Sweeney MH [1996]. Tradeswomen’s perspectives on occupational health and safety: a qualitative investigation. Am J Ind Med 29:516-520.

Goldenhar, L.M. and Sweeney, M.H [1996]. "Tradeswomen's Perspectives on Occupational Health and Safety: A Qualitative Investigation.*" American Journal of Industrial Medicine*, 29(5): 516-520.

Conference Papers and Presentations

Goldenhar LM [1998]. Health and Safety for Tradeswomen: Report of HASWIC. Massachusetts Construction Safety Congress. Boston MA, September 29-30, 1998 (Invited Presentation).

Goldenhar LM [1998]. A Comparison of Some Health and Safety Attitudes and Beliefs of Men and Women in Construction Construction Safety Council - Safe Site 98. Chicago, Illinois. February 18, 1998. (Invited Presentation).

Goldenhar, L.M., Hurrell, J.J., Swanson, N., Ruder, A., and Deddens, J [1996]. *Effects of On-the-Job Harassment: Outcomes for Women Construction Workers. Preliminary Survey Findings.* Presented at APA-CDC Conference on Women's Health, Washington DC, September, 1996.

Sub goal 4.3 Optimize the role of safety and health in construction training efforts

A) Issue

Training is valued and ingrained within construction, not only for developing basic skills but for keeping abreast of new methods and materials. The importance of safety and health training has long been recognized as an essential tool for raising construction worker awareness and for developing skills for recognition, prevention, and control of hazards. The self-directed nature of work (predominantly small and self-employed mobile contractors), transient nature of work (cyclical, temporary employment), and mobile and dynamic work sites make training important to the industry. With varying levels of specificity and effectiveness, training programs and strategies are viewed as integral functions to construction industry culture.

Unionized construction workers, laborers, and skilled trades workers in organized apprenticeship programs receive formal training [Sokas et al. 2007]. Regulatory requirements and compliance-driven standards for the industry also result in training activities [Robins et al. 1990; Cohen and Colligan 1998]. The Construction Program had worked in the following areas:

- Building a training infrastructure
- Training as an intervention, and
- Training effectiveness evaluation.

B) Activities

Building a Training Infrastructure

In 1993, the Construction Program convened a national construction safety and health conference. Participants developed a national construction safety and health research agenda [CPWR 1994]. They identified joint labor-management initiatives as an important approach for training. Based on this conference, the Construction Center researchers (formally designated in 1995) began engaging construction unions and employers to develop a standardized training program with a national joint labor-management committee. Through the 1990s, this committee was co-chaired by Robert Georgine, President of the Building and Construction Trades Department, AFL-CIO and CPWR, and Robert McCormick, Executive Director of the National Constructors Association. Members included representatives from each of the 15 international/national construction unions and seven large, national contractor associations. In all, the committee represented more than 3 million workers and 40,000 construction employers nationwide.

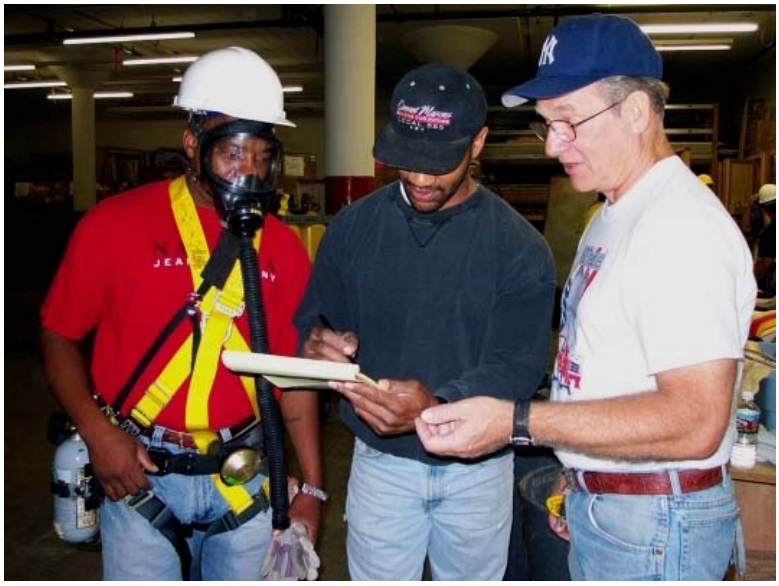
Working with a subcommittee of the joint committee, in 1995, the Construction Center collected and reviewed existing safety and health training programs and developed a curriculum outline for a new 10-hour standardized safety and health training program for the industry. It was later named the Smart Mark program.

The Construction Program has also worked to develop a tool targeting the health and safety of young workers while they are in school. Although prohibited from performing many of the high-risk activities in the construction industry, many young workers pursue education and vocational training in construction trades. Young workers have up to two-to-three times higher worker injury rates than older workers. In one study, more than half of the injured adolescent workers reported that they had not received any training in how to prevent the injury they sustained [Schulte et al. 2005]. These injuries can happen while individuals are still in school. To address this deficiency, a CD-ROM training and resource tool was developed in 2003. The Safety Checklists Program for Schools and Other Safety Databases [NIOSH 2004a] is a training resource intended for use by educators, supervisors, and superintendents of high schools, career and technical schools, and community colleges, as well as by professors at colleges and universities to ensure that their programs adhere to safety and health regulations and guidelines. The safety checklists program is based on 82 safety checklists that are derived from OSHA and EPA regulations. It guides users with no occupational safety and health background in setting up and running a safety and environmental program at their vocational or technical schools. Resources include occupational safety and health curricula and many HTML links to useful organizations and agencies, such as NIOSH, OSHA, and the EPA.

During development and revision of the NIOSH Safety Checklists Program for Schools and Other Safety Databases, the CD-ROM was independently evaluated for its usability in 2006 by the University of Medicine and Dentistry of New Jersey. Respondents found the CD to be useful (38%) or very useful (44%) and reported using the CD to educate students, develop safety and health programs, and conduct inspections. Respondents also described the CD as being user-friendly. The CD-ROM competed for NIOSH's Alice Hamilton Award. It received second place in the educational materials category in 2004, and an r2p award (second place) in 2005. It was also nominated for the CDC Health Communications competition in 2005.

Training as an Intervention

In 1996, Construction Program researchers and stakeholders studied the utility of mortality studies as a training tool [Robinson et al. 1995]. We worked with union management to identify potential training opportunities at conferences and apprenticeship programs. Focus groups of sheet metal construction workers were recruited for the training exercise. The goals of the groups were: (1) to identify illnesses and injuries that sheet metal workers believe may have been caused or exacerbated by job activities; (2) to identify current hazards that need prevention and to identify possible strategies for intervention; (3) to communicate results of a mortality study of sheet metal workers; and (4) to encourage dialogue between sheet metal workers and researchers. In eight focus group sessions, a total of 57 sheet metal workers attending the International Training Institute Conference (Portland, Oregon, December 3-5, 1998) participated. Evaluation of transcripts from the sessions showed that participants experienced work-related stress and other health and safety risks as a direct or unavoidable consequence of sheet metal work and structure of industry, job responsibilities, and substance abuse issues.



The construction center conducted a three year study examining the differences in training and self-protective practices between painters in Alaska subject to mandatory training and Washington and Oregon where such training is voluntary. Among other findings, the study demonstrated that safety and health training improves respirator and ventilation use and mandatory training is more effective that voluntary training in improving self-protective practices and reaching workers [Wolford, et al 1997].

While the extent and effectiveness of training provided by organized labor have been fairly well characterized [Sokas et al. 2007], little is known about the quality and nature of safety and health training available to open-shop (nonunion) construction workers. To address this deficiency, Construction Program

researchers, in partnership with the Institute for Health Policy and Health Services Research, University of Cincinnati Medical Center surveyed 45 open-shop construction companies [Goldenhar et al. 2001]. Analyses of survey results found that although the majority of contractors surveyed did provide safety and health training, most did not quantitatively evaluate their training programs in terms of reduction in hazardous behaviors or exposures, or increased job satisfaction or productivity. The researchers noted that learning about the major parameters (e.g., methods, policies, barriers, company/worker perceptions) influencing nonunion construction safety training will help guide future construction safety-related research and intervention strategies on a national basis.

Training Effectiveness Evaluation

In construction and mining, one widely used approach to safety and health training is toolbox safety talks. These talks are brief (10-to-20-minute) discussions attended by a small group of employees (5 to 10 individuals). Despite the growing use of toolbox safety talks and the potential of this approach for providing industry with an affordable method of training, little research has evaluated its effectiveness. Construction Program researchers began a project in 2001 to evaluate the effectiveness of NIOSH toolbox safety training programs for residential construction and sand and gravel mining. By comparing narrative (case studies) and conventional (fact-based) instructional methodologies, the study was intended to determine whether the inclusion of case studies in safety training will enhance employee learning and workplace performance. Analysis of data from participants representing the construction sector is ongoing.

Construction Program researchers began a project in 2004 to identify barriers to training in small construction businesses that employ family members and close acquaintances. This project is studying the needs of this community in order to develop more effective training and work systems. Recommendations are provided to OSHA Outreach Training Programs for small construction firms. The researchers used a Macroergonomic Analysis and Design (MEAD) method [Hendrick and Kleiner 2001] to analyze the design of work systems. The method can be applied to collect direct feedback data from workers who are employed by small construction firms. These data are used to identify specific needs, barriers, and preferences for small groups of workers. A participatory design team of representatives from small construction firms was recruited for this ongoing effort to design effective training systems, more formalized work systems (organizational strategies), and to provide recommendations for OSHA and other outreach groups.

With the success of the Construction Center researchers' development and dissemination of the 10-hour Smart Mark hazard awareness training modules, efforts focused on evaluating how these training materials were perceived by users. In 2004, a web-based survey of outreach trainers was developed through key informant interviews with master trainers, members of the Construction

Center Advisory Board and its training experts. The Construction Center introduced and distributed the web-based survey, which was completed online by 27% of the recipients of the e-mails. In addition to satisfaction with specific modules, suggestions for improvement, and other comments, trainers were asked a series of questions about their trainees, including hazards faced, language spoken, and estimated impacts of training.

Construction Center researchers have also studied the intermediate outcomes of 10-hour hazard awareness training, including knowledge, attitude and self-reported safety practice changes, as well as impact on injury outcomes. In 2004, a pilot project was begun to collect data on these variables and to identify the sample size necessary to assess injury outcome changes. Building on results of surveys of master and outreach trainers, questionnaires were developed for workers.

Construction Center researchers have also evaluated the impact of hazard awareness training on Spanish-speaking construction workers [Ruttenberg and Lazo 2004]. Spanish-speaking construction workers (n=47) were interviewed for one to two hours between 12 and 18 months following training. The research focused on effects of language barriers, construction experience from outside the United States, outcomes of training, and ways to improve training.

C) Outputs and Transfer

Construction Program researchers authored a total of 9 peer reviewed journal articles on this topic, provided 2 presentations, and developed 12 NIOSH and Center publications. (A detailed listing of these is provided in Appendix 4.3)

The effort to coordinate national labor-management committee meetings and other activities led to a national training initiative that continues to grow annually. Building on the Center researchers' work in creating and launching the initiative, the committee applied for and received $150,000 from the Federal Mediation and Conciliation Service to develop the training curriculum. The first 10, 1-hour modules were developed; the materials were copyrighted under the brand name, Smart Mark*;* and the committee member organizations contributed approximately $400,000 for the printing of instructor kits, support training materials, and student booklets.

The national Smart Mark training initiative was launched in 1998. The program continues to be administered by the Building Trades Department, with support from the Construction Center. More than 60,000 construction workers are now trained in Smart Mark annually. Since its launch, four additional 1-hour modules have been developed and added to the Smart Mark training menu. More than 4,000 building trades union instructors are now certified to teach the Smart Mark training program nationally. Owners, such as the Tennessee Valley Authority (TVA), which employees up to 15,000 construction workers at any given time,

require workers to have the Smart Mark training program on all of its jobsites; the Building and Construction Trades Department, AFL-CIO has negotiated large project labor agreements making the 10-hour training program a condition of employment; and several states, such as Connecticut and Massachusetts, require by law the 10-hour program on projects over a certain size in terms of dollar value. These state initiatives were pushed by labor and management representatives based on the success of the Smart Mark program, in terms of its quality and ability to deliver the training.

Results of a pilot project surveying outreach trainers to evaluate the hazard awareness modules for Smart Mark were compiled into a detailed report for the construction Center. This report allowed the Smart Mark program developers to review specific responses for all questions. The evaluation results were described in APHA presentations in December 2005 and a peer-reviewed publication [Sokas et al. 2007].

As part of the effort to evaluate the Smart Mark training, finalized versions of the trainee questionnaire and improvements in administration methods have been created. A NORA poster presentation (September 2005) compared U.S.-born roofers with foreign-born Latino and U.S.-born Latino roofers and determined that, controlling for age and years in the union, prior workplace safety training was associated with increased odds of identifying a hazardous situation at work and doing something about it, and that this was as true of foreign-born Latino workers as it was of U.S.-born workers. Additional output and transfer activities for the evaluation include: a Master's student capstone project (Emile Jorgensen); a peer-reviewed paper (Jorgensen EZ, Sokas RK, Nickels L, Gao W, Gittleman JL [accepted]: An English/Spanish Safety Climate Scale for Construction Workers); and a workshop at the national BuildSafe Conference in Chicago (February 2007) to describe the use and importance of the safety climate scale.

The Safety Checklists Program for Schools and Other Safety Databases [NIOSH 2004a] was distributed to hundreds of school teachers and occupational safety and health professionals for evaluation and revision. A beta-version of the CD-ROM contents was uploaded on the NIOSH website in 2003 for 10 weeks for public review and comments. After revision, 64,500 CD-ROM copies were disseminated from January 2004 to August 2006. Dissemination was resumed after it was revised and updated again in 2006. Eleven million students attend 20,000 vocational high schools and community technical colleges in the United States. Targeting that audience, the dissemination strategy for this product has been focused on outreach to the school administrators, supervisors, teachers and instructors, and then to the students. Dissemination has involved collaboration with partners and stakeholders in vocational-technical education, and the safety and health community.

D) Intermediate and End Outcomes

Building a Training Infrastructure

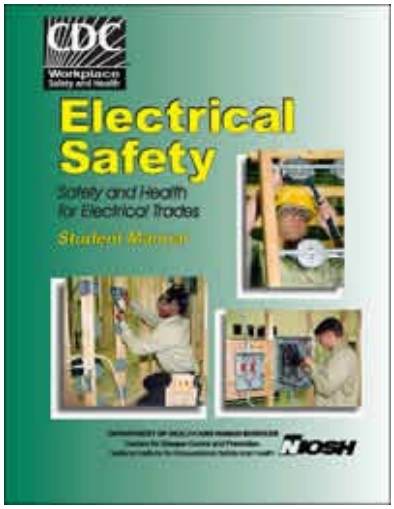
The success of the Smart Mark program, initially developed with seed money from the Construction Center program, has been demonstrated through its adoption by construction project owners (Tennessee Valley Authority employing more than 15,000 construction workers on a given day) and states (Connecticut, Massachusetts) and the number of construction workers (approximately 60,000/per year with more than 500,000 workers trained since program inception) who are trained and certified according to the Smart Mark program. Intermediate customers associated with Smart Mark are construction owners and users, employers, unions, and joint labor/management training centers, among whom are 4,000-5,000 training instructors certified to teach the Smart Mark training program.

Institutionalization of NIOSH-generated Resources

Reference material incorporated by Construction Center research collaborators into institutional training programs has a major impact in construction worker safety and health. Construction Center research collaborators have trained more than 300,000 workers in hazardous waste worker training programs using the NIOSH Pocket Guide to Chemical Hazards.

Training programs generated by Construction Center researchers in occupational contact dermatitis among workers exposed to wet portland cement have been integrated into national training programs of the Operative Plasterers and Cement Masons' Union (40,000 members), the Bricklayers' and Allied Craftworkers' Union (95,000 members) and the Laborers' International Union of North America (660,000 members). CoNA Subgoal 2.5 (Dermal exposures and various skin disorders in construction) further characterizes this Construction Center research program.

Other training programs generated by Construction Center researchers have been institutionalized in the Building Trades' national apprenticeship and training infrastructure, the mechanism for reaching more than 3 million organized construction workers in the United States. Individual discussions of Construction Center-generated training programs can be found in the write-ups under other sub goals in this document, including Power Line Safety Training Program, Fall Safe Program, Electrical Safety Student Manual, Trench Safety Awareness Training, and the *Don't Fall for It* video.



E) External Factors

Although training is valued for its positive effects on safety culture as well its importance for meeting compliance-driven standards, there are certainly barriers to providing training. Workers often do not get paid to go to training, or training is conducted outside of work hours or on weekends. The mobility of workers among multiple worksites and a moderately high turnover in employees creates challenges for training intervention and evaluation of training effectiveness. Other factors can be linked to the changing demographics of the construction industry (immigrant workers, older workers), communication challenges, and a broadly dispersed industry comprised primarily of small business and self-employed contractors. Among the positive external factors is the development and adoption of effective training programs (e.g., Smart Mark), the role of regulatory requirements for worker safety and health training, and joint labor/management committee funding of $700 million per year to train construction workers.

F) What's Ahead?

For Construction Program researchers evaluating the utility of toolbox talks in construction and mining, data analyses are ongoing. The study objective is to reveal the impact of the inclusion of stories (also termed narratives and case studies) in toolbox safety talks. This in turn will determine whether the use of stories is an effective and easy-to-use strategy for enhancing toolbox safety talks. The evaluation results and significant findings will be published in the peer-reviewed literature and the materials will be disseminated through appropriate sector-based routes including the NIOSH website. Fifty-two toolbox talks (number of talks used in one year) will be developed for both construction and mining, and will be designed based on information gathered from the study. A non-technical report that reflects the findings of relevance to the safety training concerns of these industries will be prepared and shared with study participants. Intermediate customers to be served by these products include mining and

construction companies who may use the findings and sets of toolbox talks to enhance their safety and health training programs.

Construction Program researchers are also continuing an effort to identify and compare training needs for small construction companies of varying ethnic ownership. Planned outcomes for this study include the following:

- Generic training system customized to the needs of workers in informal work systems
- Case studies derived from interviews and critical incidents (broad to protect workers)
- Design specifications for training tools such as videos or brochures
- Process and structural flow charts to support effective work system design
- Recommendations for best practices related to organizational design and safety climate
- Recommendations for interventions by health and safety training groups or OSHA outreach efforts for small businesses

NORA Construction Sector Training Issues Topic Area
The National Occupational Research Agenda (NORA) Construction Sector Council was formed in 2006. The Council is comprised of stakeholders and subject matter experts from government, academia, industry groups, organized labor, and private consulting. At Council meetings, priority topic areas were identified through discussions and multi-voting. Training was identified as one orf ten selected topic areas. A workgroup was formed from volunteers on the Council with interest and experience in training. Additional corresponding members were recruited. The workgroup is charged to provide leadership in the development of priorities for addressing research needs in construction safety and health training.

References

CPWR [1994]. An agenda for change: Report of the National Conference on Ergonomics, Safety, and Health in Construction, July 18-22, 1993, Washington, DC. Report Number G2-94, The Center to Protect Workers' Rights, Washington, D.C.

CPWR [2002]. The U.S. construction industry and its workers, 2002. http://www.cpwr.com/indexstart.html. Accessed 8/17/06.

Cohen A, Colligan MJ [1998]. Assessing occupational safety and health training: A literature review. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention,

National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 98-145.

Dong X, Entzel P, Men Y, Chowdhury R, Schneider S [2004]. Effects of safety and health training on work-related injury among construction laborers. Journal of Occupational and Environmental Medicine *46*:1222 1228.

Goldenhar LM, Moran SK, Colligan M [2001]. Health and safety training in a sample of open-shop construction companies. Journal of Safety Research *31*:237 252.

Hendrick HW, Kleiner BM [2001]. Macroergonomics: An introduction to work system design. Health Factors and Ergonomics Society Publications, Santa Monica, CA.

Jorgensen EZ, Sokas RK, Nickels L, Gao W, Gittleman JL [accepted]. An English/Spanish safety climate scale for construction workers.

NIOSH [2004a]. Safety checklists program for schools and other safety databases. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2004-101.

NIOSH [2004b]. Worker health chart book*,* 2004. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2004-146.

Pollack ES, Chowdhury RT [2001]. Trends in work-related death and injury rates among U.S. construction workers, 1992-1998. Silver Spring, MD: The Center to Protect Workers' Rights.

Robins TG, Hugentobler MK, Kaminski MA, Klintzman S [1990]. Implementation of the federal hazard communication standard: Does training work? Journal of Occupational Medicine *32*:1133 1140.

Robinson CF, Halperin WE, Alterman T, et al. [1995]. Mortality patterns among construction workers in the United States. Occupational Medicine *10*:269 283.

Ruttenberg R, Lazo M [2004]. Spanish-Speaking construction workers discuss their safety needs and experiences: Residential construction training program evaluation report. The Center to Protect Workers' Rights, Silver Spring, MD.

Schulte P, Stephenson C, Okun A, Palassis J, Biddle E [2005]. Integrating occupational safety and health information into vocational and technical

education and other types of workforce preparation. American Journal of Public Health *95*(3):404 411.

Sokas RK, Nickels L, Rankin K, Gittleman JL, Trahan C [2007]. Trainer evaluation of a union-based ten-hour safety and health awareness program for U.S. construction workers. International Journal of Occupational and Environmental Health *13*:56 63.

Stern F, Schulte P, Sweeney MH, et al. [1995]. Proportionate mortality among construction laborers. American Journal of Industrial Medicine *27*:485 509.

Wolford R, Larson M, Merrick D, Andrews M, Tillett S, Morris S, Keiffer M [1997]. A Comparison of Safety-and-Health Training of Painters In Alaska, Oregon, and Washington. The Center to Protect Workers' Rights, Silver Spring, MD.

Appendix 4.3 Outputs

Building a training infrastructure

Journal articles

Jorgensen EZ, Sokas RK, Nickels L, Gao W, Gittleman JL [accepted]: An English/Spanish Safety Climate Scale for Construction Workers.

Schulte P, Stephenson C, Okun A, Palassis J, Biddle E [2005]: Integrating Occupational Safety and Health Information into Vocational and Technical Education and Other Types of Workforce Preparation. American Journal of Public Health 95(3):404-411.

-NIOSH and CPWR Publications

CPWR [2002]: The U.S. Construction Industry and Its Workers, 2002. http://www.cpwr.com/indexstart.html. Accessed 8/17/06.

CPWR [1994]: An Agenda for Change: Report of the National Conference on Ergonomics, Safety, and Health in Construction, July 18-22, 1993, Washington, DC. Report Number G2-94, The Center to Protect Workers' Rights, Washington, DC.

NIOSH [2004]: NIOSH Safety Checklists Program for Schools and Other Safety Databases. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2004-101.

Ruttenberg R, Lazo M [2004]: Spanish-Speaking Construction Workers Discuss Their Safety Needs and Experiences: Residential Construction Training Program Evaluation Report. The Center to Protect Workers' Rights, Silver Spring, MD.

Additional outputs (such as Fatality Investigation Reports, Other Publications, Contractor reports, Patents, Workshops/Conferences/Meetings)

Hendrick HW, Kleiner BM [2001]: Macroergonomics: An Introduction to work System Design. Health Factors and Ergonomics Society Publications, Santa Monica, CA.

Training as an intervention

Journal articles

Dong X, Entzel P, Men Y, Chowdhury R, Schneider S [2004]: Effects of safety and health training on work-related injury among construction laborers. Journal of Occupational and Environmental Medicine 46:1222-1228.

Goldenhar LM, Moran SK, Colligan M [2001]: Health and safety training in a sample of open-shop construction companies. Journal of Safety Research 31:237-252.

Conference papers and presentations

Alterman T, Steege, A, Darragh A, Parshall M, Kidd P, Batykefer G [2000]: Focus on the Facts: Working with the Workers. Panel titled "Anthropology and Psychology AT CDC: Multi-disciplinary Contributions to Public Health Research, Evaluation and Practice", Annual Meeting of the Society for Applied Anthropology, San Francisco, CA, March.

Additional outputs (such as Fatality Investigation Reports, Other Publications, Contractor reports, Patents, Workshops/Conferences/Meetings)

Alterman T, Robinson C [1997]: Focus on the Facts: Working with the Workers. A preliminary report to the Advisory Council on Construction Safety and Health (ACCOSH), Department of Labor, Washington, D.C., June.

Training effectiveness evaluation

Journal articles

Goldenhar LM, Moran SK, Colligan M [2001]: Health and safety training in a sample of open-shop construction companies. Journal of Safety Research 31:237-252.

Robins TG, Hugentobler MK, Kaminski MA, Klintzman S [1990]: Implementation of the federal hazard communication standard: does training work? Journal of Occupational Medicine 32:1133-1140.

Robinson CF, Halperin WE, Alterman T, et al. [1995]: Mortality patterns among construction workers in the United States. Occupational Medicine 10:269-283.

Sokas RK, Nickels L, Rankin K, Gittleman JL, Trahan C [2007]: Trainer evaluation of a union-based ten-hour safety and health awareness program for U.S. construction workers. International Journal of Occupational and Environmental Health 13:56-63.

Stern F, Schulte P, Sweeney MH, et al. [1995]: Proportionate mortality among construction laborers. American Journal of Industrial Medicine 27:485-509.

NIOSH and CPWR Publications

Cohen A, Colligan MJ [1998]: Assessing Occupational Safety and Health Training: A Literature Review. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 98-145.

NIOSH [2004b]: *Worker Health Chart Book, 2004*. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2004-146.

Pollack ES, Chowdhury RT [2001]: Trends in Work-Related Death and Injury Rates Among U.S. Construction Workers, 1992-1998. Silver Spring, MD: The Center to Protect Workers' Rights.

Conference papers and presentations

Artis S, Baldev D, Tucker T, Smith-Jackson T, Kleiner-BM [2007]: Using MEAD to Analyze the Safety Training Needs of Self-Employed Construction Companies. Industrial Engineering Research Conference.

Additional outputs (such as Fatality Investigation Reports, Other Publications, Contractor reports, Patents, Workshops/Conferences/Meetings)

Baldev D *[2006]:* Design of a Construction Safety Training System using Contextual Design Methodology. MS Thesis, Virginia Tech.

Kim HN, Nussbaum MA, Seol H, Kim S, Smith Jackson TL [2006]: Risk assessment of panelized wall systems in residential construction using critical incident technique. Proceedings of the 50th Annual Human Factors and Ergonomics Conference. San Francisco, CA. October 16-20, 2222-2226.

Thomas C [2004]: Influence of acculturation and individual differences on risk judgments of construction laborers. MS Thesis, Virginia Tech.

Sub goal 4.4 Explore promising approaches for addressing construction hazards

A) Issue

NIOSH construction research relies on a common public health framework to focus on important outcomes in construction. Problems are recognized and prioritized, causal factors are identified, prevention strategies are developed and evaluated, and effective measures are transferred to intermediate and end customers. This same framework is used for all safety and health research across all industrial sectors.

However, unique conditions, opportunities and barriers in construction can strongly influence whether or not effective solutions are adopted in this industry sector. Construction Program and Center researchers seek to understand these attributes and to tailor interventions to address them. Consequently, research and intervention efforts have also explored innovative and promising approaches that appear to be especially relevant for construction. Approaches are identified via discussions with industry stakeholders, monitoring of international construction developments, and monitoring of relevant developments in other sectors.

This has led to development of construction-specific hazard exposure metrics, exploration of the role of construction project owners/managers in safety and health programs, integration of safety and health requirements into construction project specifications, and exploration of incorporating safety and health concepts and considerations into design and engineering stages. In some cases the research is integrated with work on a particular outcome. In other cases, the approach is the primary focus knowing that results can be used to inform development of interventions for important outcomes. The Construction Program has looked at several broad categories related to how construction work is organized and the relationships and responsibilities among disciplines and entities during the construction process.

B) Activities

Adapting Exposure Assessment Methods to Construction Work Organization

Occupational exposure assessment approaches have their origins in manufacturing, where assembly lines and mass production typically involve common tasks being performed each day. Traditional exposure assessment approaches focus on time-weighted averages over a full 8-hour shift. Construction Center researchers recognized early in the program history that full shift sampling for construction was much less informative given the variation that typically occurs from day-to-day and job-to-job as the work stage and location

change. In addition, construction workers more typically experience short but intense exposures associated with particular tasks. In responding to these unique factors, Construction Center researchers developed the "Task based Exposure Assessment Method" (T-BEAM) approach to provide an exposure assessment tool adapted to fit the construction setting. (This approach has been described in previous sub-goal sections 2.1 and 2.3.)

Exploratory research on construction applications of industrial hygiene methods, such as control banding, also depend on characterization of task exposures and task frequency and duration. Although control banding has been widely adopted in batch manufacturing such as pharmaceuticals, our knowledge of construction work processes remains a barrier to broader application. As our knowledge increases, control banding holds considerable promise, particularly on small projects where exposure sampling is rare. Application of control banding methods to some construction tasks in the UK and other EU countries have been explored, and NIOSH co-sponsored the Second International Control Banding Workshop (2004) and subsequently convened a National Control Banding Workshop with the American Industrial Hygiene Association (2005).

Another exposure assessment method developed to address construction setting issues involves a prototype for tracking mobile construction workers on large work sites or where travel is done between multiple areas of work sites. It links worker location throughout the workday to exposure levels from real-time monitors, using Local Positioning System (LPS) units to identify and document where to focus exposure analysis and control efforts. The goal of this effort is develop a system that could be used to identify exposure hot spots and help target interventions to reduce employee exposures. Preliminary field studies were designed to use the LPS with a multiple gas monitor, noise meter, a heat stress monitor and a photo ionization detector.

Construction Project Organization – Owner and Multiple Employer Relationships

Traditional occupational approaches and interventions address the single employer scenario common to manufacturing and other sectors. Construction stands apart in that the construction project setting involves multiple entities – from the facility owner commissioning the work to multiple contractors and subcontractors. Several research projects have addressed these issues.

Construction Program supported researchers surveyed the top 425 construction project owners in the United States to identify the means by which owners can and do influence safety performance on construction projects. The 2001 survey was followed by in-depth interviews with owners' personnel on more than 80 large (valued from $50 million to over $500 million) construction projects. Questions focused on the owners' involvement in the various aspects of the projects that were assumed to influence safety performance such as contractor selection criteria as they pertained to safety credentials, the incorporation of

safety in the construction contract, the inclusion of stipulated or mandated provisions and practices in the safety program, and the direct involvement of the owner in the safety process during construction. Detailed information was obtained about the level of safety performance achieved on each project. The study included all geographic sectors of the United States and a few international construction projects.

The result of this study was the development of a score card by which an owner on a particular construction project could be rated. The rating was intended to be a predictor of the probable safety performance on the project. The score card was validated and shown to be a reliable means to assess safety performance.

Construction Center researchers have also examined the role of procurement activity as a safety and health mechanism. The construction procurement process uses prequalification of contractors and contract language to spell out work obligations. Construction Program and Center researchers have explored the use of these mechanisms for safety and health purposes. This effort has included involvement in development of voluntary procurement and contracting guidance documents including the AIHA position statement on the *Use of OHS Performance Criteria in Contracting and Procurement*[7], and an AIHA publication on *Health and Safety Requirements in Construction Contract Documents (2005).* Construction Center researchers also had limited success in addressing construction contracting in occupational safety and health management systems consensus standards, including the ANSI Z10-2005 OHS Management Systems standard, the BSI OHSAS 18001-2007, ANSI/ISO/ASQ 19011s management systems auditing standard, and the draft ANSI A10.1 standard on planning for safety and health in construction and demolition. The use of such voluntary consensus standards is currently limited to a fairly small number of big industrial owners/clients, and is being considered by progressive innovators within the construction industry.

Another case in point involves a project wherein bid documents from public construction owners (federal, state and local) were evaluated for projects in the MD/DC/VA area in 2004. Although more than 70% of the construction program owners considered factors other than bid price (lowest bidder), fewer than 25% included prequalification criteria or contract language considering safety performance of contractors. Government contracts present important opportunities for future research to contain costs related to worker injuries and to prevent future injury and illness.

A pilot survey of 25 very large private sector owners also evaluated the use of safety prequalification of construction bidders [Hinze 2003]. More than 70% of these owners used safety-related performance criteria, some of which were quite extensive. Further research to evaluate outcomes from such requirements is needed.

[7] AIHA (2001) procurement position <http://www.aiha.org/content/accessinfo/gov/psprofcri.htm>

Agent- or hazard-specific prequalification procedures for contractors or project specifications also offer opportunities for injury and illness prevention. Lead-based paint abatement on steel structures such as bridges presents an example of such initiatives. Contractors, public owners (usually state or city transportation authorities), unions, and public health professionals can join together to develop specifications for performing this work in ways that minimize exposures. Recommended construction site specifications involving lead exposures have been adopted in Connecticut, New York, Michigan, and New Jersey. Lead and silica exposure management programs were piloted on major projects including the I-87 interchange of the Tappan Zee Bridge in New York. Blood lead levels verified the effectiveness, with the highest blood lead levels measured at baseline suggesting they were coming from jobs where controls were less effective. Broader dissemination of such model programs is ongoing.

A specific example highlights a project pre-dating the Construction Program to address occupational lead exposure related to construction and maintenance on bridges. Each year, 58,000 persons work in bridge, tunnel, and elevated highway construction and demolition jobs. About 90,000 bridges are coated with paint containing lead, creating the potential for dangerously high lead exposure to workers engaged in the maintenance, repainting, or demolition of bridges. With funding from NIOSH, Connecticut state agencies and Yale University initiated the Connecticut Road Industry Surveillance Project (CRISP) in 1990 to reduce lead toxicity in bridge workers. CRISP provided medical examinations and procedures to monitor and reduce occupational lead exposures at bridge sites; on-site technical assistance to overcome problems in reducing lead exposures; and a centralized, statewide surveillance system to monitor blood lead levels in workers. It was determined that CRISP saves Connecticut $2.5 million each year in workers' compensation costs. With CRISP, blood lead levels were decreased by 50% [CDC 1995]. Efforts are underway to implement this approach in other states.

Pre-construction Interventions – Addressing Safety and Health at the Project Design Phase

The Construction Program has also endeavored to increase the consideration and integration of safety and health concepts in the planning, design, and engineering stages of construction projects. The Design-Bid-Build (DBB) process for erecting a structure is the traditional model in the United States, although increasingly larger clients/owners are requiring more integration of design and construction. DBB typically involves a series of events:

- site owner, financial institutions, and insurance assess risk/financing
- site owner defines bidding process, bidder qualifications and award criteria
- architectural and engineering contract is drafted
- design of the structure is performed
- solicitation of construction bids from unrelated organizations is conducted

- contractors define organization (partners, subcontractors, LLC) and bid
- construction is performed by the selected (usually lowest) bidder(s)
- change orders and legal actions are negotiated as necessary.

Review of the design for constructability and potential hazards associated with building processes are seldom incorporated into this model. As a result, many hazards that could have been easily and affordably reduced at the design stage become difficult and expensive to control at a later stage. Some of the hazards are simply not anticipated and do not become apparent until workers are faced with them during the construction process. A simple example would be the specification/procurement/design of fragile skylights which will not support the weight of a construction worker. Falls through skylights are relatively common both during construction and over the lifetime of the structure. Although it is a simple matter at the design stage to specify either stronger skylights or adequate covers, a change order to address this at the construction phase becomes far more difficult. Simple engineering and procurement decisions can cascade into a large number of construction phase hazards that could have been avoided.

To address these challenges, we have supported research to gather case studies and to provide a conceptual framework for addressing safety and health at the project design phase. Conferences and forums have been supported to bring together the architects, engineers, and others to raise awareness about the potential for this approach and to develop strategies for moving forward. Publications and materials suitable for professional development have also been created.

In 2000, a multidisciplinary working group coordinated by Construction Center researchers met at Harvard University to establish research priorities on eliminating safety and health hazards at the design phase of a project. Work organization issues affecting design, such as how work was bid, and the physical and temporal separation of architects and constructors were identified and discussed, along with the need to develop specific engineering/design solutions and training/development of professionals and workers to perform design assessments.

As a related aspect of this effort, it was realized that long term change in engineering and architectural practice requires changes at the level of undergraduate education of these professionals. A Construction Center pilot study sought to characterize obstacles and opportunities to advance this long term agenda through interviews with appropriate subject matter experts and academic and professional engineers, published in a report entitled *Investigation of the Viability of Designing for Safety* [Gambatese 2005].

In the near term, prevention of injury through pre-construction design and engineering requires action by practicing professionals. Construction Center initiatives have included case study assessments of construction equipment,

documentation of and structural design issues and related legal issues, and exploration of alternative designs [MacCollum, 2005]. A key reference volume was developed [MacCollum 2006] which provides a process (5 principles) to guide professional engineers to consider of safety and health implications in design. .

Through the use of an integrated design process, such as the Life Cycle Safety (LCS) initiative, improvements in safety and health for workers can be considered at every stage of occupational activity at a given facility, including construction [Hecker 2003]. This initiative combined the input of designers, contractors, and end-users, integrating a focus on the safety of construction workers.

This process was applied to the construction of a large industrial plant. Design elements for the new plant were reviewed by construction contractors and the personnel who would be operating and maintaining the plant after it was built. These specialists have the knowledge and experience to identify areas where design changes could improve the safety of workers who would construct the plant and those who would work there after construction. This process was contrary to traditional procedures, in which specialists would not have been involved so early in the design process.

The researchers found both general and specific benefits to the LCS process:

- Designers and contractors reported that the close collaboration and communication resulted in improvements in sequencing, scheduling, and quality as well as safety during the construction of the plant.
- Outcome evaluation identified specific cases in which LCS safety reviews resulted in or contributed to added safety measures including added space for staging and access for construction workers, the addition of fall protection anchorage points, and off-site fabrication to reduce on-site exposures. Analyses are being done to examine these successes as well as cases in which safety issues were identified but not fully addressed.
- By building safety into the design of the structure, the partnership reduced the risk of employee injuries and potentially helped the owner avoid costly post-construction work to eliminate awkward or hazardous design features once the plant was completed.

This LCS effort was nominated for the 2003 NORA Partnering Award.

The Construction Center collaborated with investigators on a 2003 conference on Designing for Safety and Health in Construction [Hecker 2004] that highlighted local initiatives such as LCS and involved architects and engineers/designers from the EU and US design-build sector to present specific project case studies of constructability/safety reviews. This highlighted several challenges and opportunities for injury prevention.

Understanding construction economics – how costs influence safety and health

Construction is highly competitive and contracts are typically based on the lowest bid. Stakeholders at early national construction conferences suggested that understanding economic factors and their relationship to improved safety and health was important. In response, the Construction Center established a Construction Economics Research Network (CERN) of approximately 40 academic economists engaged in research related to the construction sector. This has improved collaboration and advanced an economic research agenda in an industry sector where research presents significant challenges. This continues to be a priority area, but the construction sector offers unique challenges because of limited centralized data collection, challenges in defining nationally representative samples of employers or workers, and the exclusion of self employed workers (approximately a quarter of the construction workforce) from employer data collection. State and locally targeted data sets offer opportunities for expanded research to define the context within which a proposed public health intervention must succeed.

C) Outputs and Transfer

Construction Program researchers authored a total of 7 peer reviewed journal articles on this topic, provided 11 presentations, and developed 10 NIOSH and Center publications. (A detailed listing of these is provided in Appendix 4.4.)

Adapting Exposure Assessment Methods to Construction Work Organization

Construction Center researchers introduced the task based approach to assessing hazardous exposures in construction in the late 1990s (Susi 1995, Goldberg 1997, Susi 2000). Subsequent papers utilizing this approach have been authored on the use of this approach for characterizing noise exposures, silica, welding fumes, and other agents. Numerous presentations of research using this approach have resulted in broad acceptance of TBEAM as a best practice for work places where tasks and exposures are intermittent, even though OSHA regulatory compliance and most recommended limits including NIOSH RELs remain based on time weighted average exposures, and for a few agents ceiling levels.

Construction Center researchers also introduced the PATH approach during the same time period. In some ways this provides a method for characterizing ergonomic risk which parallels the TBEAM industrial hygiene sampling approach. This has led to simplified second generation ergonomic risk data collection tools.

Pre-construction Interventions – Addressing Safety and Health at the Project Design Phase

In the course of performing research and intervention activities relating to this initiative, a broad range of presentations, publications, and other information dissemination campaigns have resulted. Selected examples are provided below:

Conference: Designing for Safety and Health in Construction. Portland, Oregon. September 2003. (Proceedings: Hecker S, et.al [2004]: Designing for Safety and Health in Construction.)

Conference: Designing Out the Hazards. February 2006. Sierra Vista, AZ.

MacCollum D [2006] Inherently Safer Design Principals in Construction.

McCollum D, Meyers M [2006]: Construction Safety Engineering Principles.

MacCollum D [2006]: Safety Interventions to Control Hazards Related to Power Line Contacts by Mobile Cranes and Other Boomed Equipment..

D) Intermediate and End Outcomes

Adapting Exposure Assessment Methods to Construction Work Organization

A task-based approach to characterizing construction exposures has been adopted by researchers and practitioners, providing an indication of broad acceptance of TBEAM as a best practice for work places where tasks and exposures are intermittent.

Construction Program researchers enlisted legal counsel to submit a patent application for the LPS tool and real-time monitoring process. The patent is pending, the issue fee has been paid and was verified by PTO as received on 2/2/07, and PTO is to assign a number. (CDC Ref. No. I-017-03, Gifford Ref. No. CDC-10902/38, US Application 10/815,111.)

Construction Project Organization – Owner and Multiple Employer Relationships

The information from a survey of owner practices that have a positive or favorable impact on safety performance on construction projects has been shared extensively with the Construction Industry Institute (CII), a membership organization of contractors, academics, and approximately 50 owners with sizable construction budgets. The survey findings have been included in a commercial educational module on construction safety that was prepared for the CII. This module has been taught a number of times with very favorable results. The information from the research is continuing to be widely publicized by the CII as part of its zero injury initiative. Several large facility owners with substantial construction budgets have reported implementation of suggestions and recommendations attributed to this research.

Pre-construction Interventions – Addressing Safety and Health at the Project Design Phase

The Construction Program and Center activities have contributed to design gaining traction as an accepted approach and to an increase in design-related activities by other stakeholders. For example, in 2006 OSHA approved a Design for Safety Alliance comprised of invited stakeholders and researchers, many of whom are involved in the Construction Program and Centers. This provides a quarterly forum for discussion of these issues on a national scale.

The Washington Group International (WGI) has customized the design for safety materials and delivered full-day training programs using corporate resources to more than 500 (as of spring 2007) of its engineers globally. WGI plans to continue this program until all 1,800 of its engineers globally have received basic design for safety training. Also in 2007, WGI described the concepts and objectives of Five Principles of Inherently Safer Design [MacCollum D 2006] at the OSHA Roundtable for Designing for Safety. At this meeting, the OSHA Directorate of Construction strongly recommended the use of the McGraw Hill textbook Construction Safety Engineering Principles [MacCollum and Meyers 2006] as a source of methodology to ensure for safety design of construction projects. This publication is a critical resource for reaching out to practicing professional engineers and students.

The Construction Safety Council annual conference (Rosemont, IL, February 2007) included several sessions on design, continuing a dialog since at least

2003 to improve the understanding of design for safety in the construction safety and health practitioner community.

E) External Factors

Civil, structural, and mechanical engineers and architects continue to have significant concerns related to liability and their expertise related to construction phase safety issues or means and methods of construction. Human factors engineering and many industrial engineering programs are actively engaged in design for safety in other sectors (e.g., aerospace, automotive), but to date these issues continue to be controversial in construction.

Construction organizations are commonly built anew on each project, based on a web of subcontracting and supplier relationships and partners. In many cases these might be new limited liability corporations or partnerships which are created for a specific project. It is also increasingly common to see self-performing general contractors replaced with construction management firms who may not employ any production construction workers.
As a result, organization and scheduling of work is primarily defined in multi-employer or employer-client negotiations. Our knowledge of how these organizational structures may impact safety practices or adoption of injury prevention interventions remains minimal.

Most construction is highly competitive with narrow profit margins. Access to economic data, and even collection of work sampling data, can be seen as disclosure of proprietary information that may affect the success of future competitive bids. This presents challenging barriers to researchers attempting to engage a representative sample of construction employers or workers nationwide.

F) What's Ahead?

Draft NIOSH construction program goals include intermediate goals for falls related to procurement and design interventions. The NORA Construction Sector Council also selected design issues in construction as a top problem topic. The issue was later renamed as the *Construction Hazard Prevention Through Design (ChPtD) Topic Area*. This topic was determined to be a priority area for assessing research needs as well as the effective translation and dissemination of best practices for preventing hazards in construction through design and engineering to minimize hazards. A core workgroup formed from volunteers on the Sector Council with interest and experience in this topic area has begun to focus on setting goals and performance measures to reduce hazards and improve safety and health in the construction industry through decisions made and communicated as they relate specifically to design processes at the project planning stages.

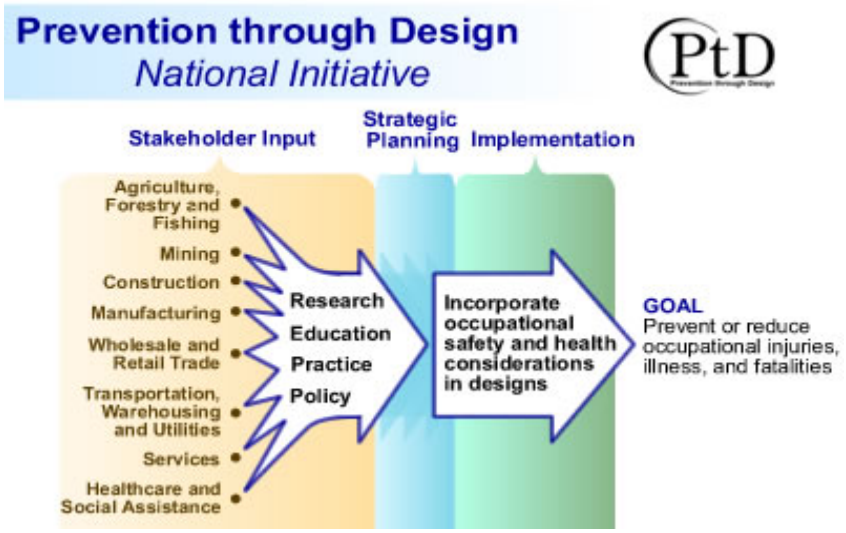
Planned Pilot Projects

- Impacts of Green Building Design and Construction on Worker Safety and Health. J Gambatese, Oregon State University (2007-8).
- Construction Safety Consideration in Contracting with Architectural and Engineering Firms. M Toole, Bucknell University (2007-8).
- Performance Measures for Safety and Health in Construction. G Piacitelli, J Gittleman, J Boiano, NIOSH/CPWR (2007).

Planned Transfer Activities

Prevention through Design (PtD) Workshop and National Strategy. NIOSH (2007), http://www.cdc.gov/niosh/topics/ptd/ .
Although this initiative targets all industry sectors, construction is a major audience comprised of the following:

- Health and safety professionals
- Design build firms
- Academic and practicing engineers and other researchers
- Architects/designers
- Progressive owners and construction managers
- Construction trades workers and employers
- Other stakeholders.



References

CDC [1995]. Controlling lead toxicity in bridge workers—Connecticut, 1991–1994. Centers for Disease Control and Prevention. MMWR *44*(4):76 79.

Susi P, Schneider S [1995]: Database needs for a task-based exposure assessment model for construction. Appl Occup Environ Hyg 10: 394–9.

Goldberg M [1997]:A task-based approach to assessing lead exposure among iron workers engaged in bridge rehabilitation. Am J Industr Med 31(3): 310-318.

Susi P, Goldberg M, Barnes P, Stafford E [2000]: The Use of a Task-Based Exposure Assessment Model (T-BEAM) for Assessment of Metal Fume Exposures During Welding and Thermal Cutting. Appl Occup Environ Hyg 15(1): 26 – 38.

Hecker S, Gambatese J [2003]: Safety in Design: A Proactive Approach to Construction Worker Safety and Health. Appl Occup Environ Hyg 18(5): 339 - 342.

Hinze J [2003]: The owners' role in construction safety. Research summary 190-1, Construction Industry Institute, March.

Hecker S, Gambatese J, Weinstein M [2004]: Designing for Safety and Health in Construction: Proceedings from a Research and Practice Symposium. University of Oregon Press, Eugene, Oregon.

Gambatese J, et. al. [2005]: Viability of Designing for Construction Worker Safety. J Constr Engin Mgmt 131(9): 1029-1036.

MacCollum DV [2006]: Inherently safer design: Five principles for improving construction safety. Professional Safety, May:26-33.

MacCollum D, Meyers M [2006]: Construction safety engineering principles. McGraw Hill Publishing, New York.

Appendix 4.4

Outputs

Adapting exposure assessment methods to construction work organization

Journal articles

Goldberg M [1997]: A task-based approach to assessing lead exposure among iron workers engaged in bridge rehabilitation. Am J Industr Med 31(3): 310-318.

Lee LA, Soderholm SC, Flemmer MM, Hornsby-Myers JL [2005]: Field test results of an automated exposure assessment tool, the local positioning system (LPS). J Environ Monit 7:736-742.

Susi P, Schneider S [1995] Database needs for a task-based exposure assessment model for construction. Appl Occup Environ Hyg 10: 394–9.

Susi P, Goldberg M, Barnes P, Stafford E [2000]: The Use of a Task-Based Exposure Assessment Model (T-BEAM) for Assessment of Metal Fume Exposures During Welding and Thermal Cutting. Appl Occup Environ Hyg 15(1): 26 – 38.

Conference papers and presentations

Hornsby-Myers J, Lee L, Flemmer M, Gali R, Soderholm S [2003]: Initial Field Testing of a System Using GPS and Near-Real-Time Monitors for Exposure Assessment. American Industrial Hygiene Conference and Exposition (AIHCE), May. (Awarded “Best of Session” in the Exposure Assessment Session.)

Hornsby-Myers, JL, Lee LA, Flemmer MM [2002]: Field testing of local positioning system. Poster presentation at Salt Fork X, Mineral Wells, WV.

Construction project organization – owner and multiple employer relationships

Conference papers and presentations

Hinze J. [2003]. Practice that Enhance Safety Performance on Large Projects. Construction Institute Day, Nashville Civil Engineering Conference & Exposition, Nashville, TN, November 14.

Hinze J. [2003]. Effective Practices to Achieve Zero Injuries on Projects. Midwest Construction Conference, Construction Institute, Minneapolis, MN, May 2003.

Additional outputs (such as Fatality Investigation Reports, Other Publications, Contractor reports, Patents, Workshops/Conferences/Meetings)

Hinze J. [2003]. The Owners’ Role in Construction Safety. Research Summary 190-1, Construction Industry Institute, March 2003.

Pre-construction interventions – addressing safety and health at the project design phase

Journal articles

Gambatese J., et. al. [2005]: Viability of Designing for Construction Worker Safety. J Constr Engin Mgmt 131(9): 1029-1036.

Hecker S and Gambatese J [2003]: Safety in Design: A Proactive Approach to Construction Worker Safety and Health. Appl Occup Environ Hyg 18(5): 339 - 342.

MacCollum DV [2006]: Inherently Safer Design: Five Principles for Improving Construction Safety. Professional Safety, May:26-33.

NIOSH and CPWR Publications

Behm M [2005-6]: An Analysis of Construction Accidents from a Design Perspective. CPWR Report and Oregon State University PhD Thesis.

Gambatese J, et al. [2005]: Investigation of the Viability of Designing for Safety. CPWR Report, The Center to Protect Workers' Rights, Washington, DC.

MacCollum D [2006]: Safety Interventions to Control Hazards Related to Power Line Contacts by Mobile Cranes and Other Boomed Equipment. CPWR Report, The Center to Protect Workers' Rights, Silver Spring, MD.

MacCollum D, Meyers M [2005]: Inherently Safer Design Principles in Construction. CPWR Report, The Center to Protect Workers' Rights, Washington, DC.

Conference papers and presentations

Behm M [2005]: Design for Construction Safety: An Introduction, Implementation Techniques and Research Summary. Presentation at Safety 2005. New Orleans, LA.

Gruska M, Hughes R, Ellis N [2007]: Five Principles of Inherently Safer Design. Construction Safety Council Conference, Chicago, IL.

Hecker S, Gambatese J [2004]: Collaboration in Design to Promote Construction Safety. Construction Safety Conference, Chicago, IL.

Hughes RR, HIFI and University of Alabama at Auburn [2006]: Continuing education program to allow engineers to meet state engineering license renewal requirements. Construction Safety Council Conference, Rosemont, IL, May.

MacCollum, Callor, Middendorf [2007]: Six hour professional development session on the Five Principles of Inherently Safer Design. Oregon Governor's Safety Conference. Portland, OR, March.

Toole M, Platner J [2007]: Design for Safety and CPWR Construction Research Initiatives. Construction Users Roundtable, Safety Committee. Ypsilanti, Michigan.

Additional outputs (such as Fatality Investigation Reports, Other Publications, Contractor reports, Patents, Workshops/Conferences/Meetings)

CPWR/Harvard. Forum on Broadening the Prevention Research Agenda: Occupational Injury and Illness in the Construction Industry." Briefing book for a working group in Cambridge, MA. March 30-31, 2000. Section on "Design, Architecture and Engineering" pp. 60-141.

Gambatese J [2000]: Safety Constructability: Designer Involvement in Construction Site Safety. In *Proceedings of Construction Congress VI.* Reston, VA: American Society of Civil Engineers:650-660.

Hecker S, Gambatese J, Weinstein M [2004]. Designing for Safety and Health in Construction: Proceedings from a Research and Practice Symposium. University of Oregon Press, Eugene, OR.

MacCollum D, Hughes R [2005]: *Building Design and Construction Hazards.* Tucson, AZ: Lawyers and Judges.

MacCollum D, Meyers M [2006]: Construction Safety Engineering Principles. McGraw Hill Publishing, New York.

Sub goal 4.5 Improve diffusion of safety and health research to construction practice

A) Issue

The tangible benefits from construction safety and health research occur when research findings are used by construction stakeholders such as workers, contractors, unions, and professionals. Getting safety and health information to construction stakeholders is challenging, especially to the small-and medium-sized firms that make up the majority of the industry. For example, small firms are less likely to have full-time safety and health professionals, meaning that information conveyed via traditional information channels, such as professional peer-review journals, are ineffective. The issue of transferring research information more effectively has been of increasing interest throughout government and NIOSH developed an institute-wide “Research to Practice” (R2P) initiative in 2005.

The Construction Program recognized that collaboration with industry partners was integral to diffusion and the use of national conferences and stakeholder consultation was established from the beginning. Strategies to improve diffusion have evolved over time. For example, the Construction Program used the 2003 Cooperative Agreement RFA to suggest that 20% of direct costs be targeted to “translation” projects to move research results into products or practices for construction customers. This has led to projects using social marketing and communication science approaches to increase understanding of how best to diffuse safety and health concepts and practices into the construction workplace. These projects, some of the first-ever diffusion projects supported by NIOSH, are expected to inform and improve Program diffusion practices. Key ongoing diffusion activities are described further below.

B) Approach

(eLCOSH) electronic Library of Construction Occupational Safety and Health

Construction Program and Construction Center researchers began collaborating in 1997 about how best to take advantage of the Internet for improving access to safety and health materials. An electronic clearinghouse for safety and health information offered a mechanism for facilitating delivery to a dispersed and mobile construction audience. The *electronic Library of Construction Occupational Safety and Health* (*eLCOSH*) prototype was developed and evaluated in 1997 and 1998 using four focus groups comprised of large and medium contractors, members of various trades, members of state and national safety councils, safety officers, insurance providers, university faculty, and construction safety trainers.

An editorial board was created to help gather appropriate materials for the site. Various print items, overhead transparencies, videos, slides and CDs were collected from a broad range of stakeholders. The project team designed the architecture based on input from focus groups on how construction end users would search for information, and the site was launched on the CDC/NIOSH website at http://www.cdc.gov/elcosh/ (also www.elcosh.org) in August of 2000. Figure 4.5.1 shows the opening eLCOSH page and the initial search categories that were identified via focus group testing as most important to users.

Figure 4.5.1 - eLCOSH Opening page

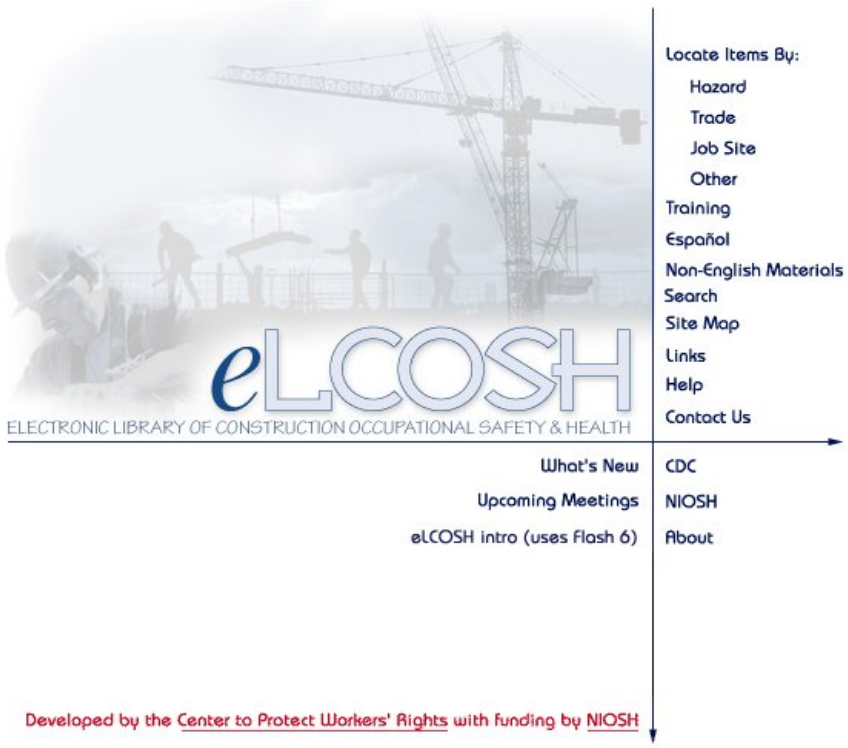


Figure 4.5.2 shows the search terms provided at the second level and Figure 3 provides an example of the types of materials available for a given topic.

Figure 4.5.2 - eLCOSH information provided at the second level page

The Web site was (and is) organized by Hazard, Trade, Job Site and Other with a separate section on Training. Searchable categories under the topics are:

Hazard: Biological, Chemical, Musculoskeletal, Physical, Safety, Other;

Trade: Asbestos/Insulator, Boilermaker, Bricklayer, Carpenter, Carpet Layer, Concrete and Terrazzo, Diver, Drywall, Electrical Worker, Elevator Constructor , Glazier, Hazardous Waste Cleanup, Heat/AC, Ironworker, Laborer, Maintenance, Mason, Millwright, Operating Engineer, Painter, Plasterer, Plumber/Pipefitter, Roofer, Sheetmetal Worker, Tile Setter, Truck Driver, Welder, All/Other;

Job Site: Commercial/Industrial Structures, Demolition, Heavy construction, Rehabilitation/Renovation, Residential, All/Other;

Other: CD-ROMs, Software, Presentations (such as PowerPoint), Checklists, Graphics (Charts, Photos, Slides, Overheads), Illnesses, Illness and Injury Prevention, Injury/Death Investigations, Miscellaneous, Musculoskeletal Disorders, Research Abstracts, Regulation, Statistics/Numbers, Videos, Women and Minorities, Work Organization;

Training: Materials, Requirements, Topics, Other.

The major headings have extensive sub-pages.
Visitors who select "**Chemical**" under "**Hazard**" get the following choices: Acid, Adhesives and Glues, Alkali, Asbestos, Asphalts, Beryllium, Carbon Monoxide, Cleaning products, Coal tar, Concrete, Dusts, Epoxy Resins, Gas, Isocyanates, Lead, Man-Made Mineral Fibers, Metals, Paints and coatings, Silica, Solvents, Solvent Substitutes, Thinners, Welding Fumes and Gases, Wood Dusts.

Figure 4.5.3 – eLCOSH – example showing types of information available for a given topic

Those who select "Concrete" under "Hazard/Chemical" can choose from these documents:

Hazard : Chemical : Concrete

- ACCSH 1994-5, exh 15, Hexavalent Chromium Recommendations
- Asbestos Containing Materials External Link
- Cement & Concrete Checklist
- Cement & Concrete Training Guide
- Cement Hazards and Controls: Health Risks and Precautions in Using Portland Cement
- Chipping the Barrel: The Hazards of Cleaning Ready-Mixed Concrete Trucks
- Contact Derm Toolbox Talk
- Curing Construction Health Woes
- Directive Aims to Protect Workers From Chromium
- An Employer's Guide to Skin Protection
- Encyclopaedia of Occupational Safety & Health : Chapter 93 - Construction Spanish
- Hazard Alert: Skin Problems in Construction Spanish
- Hexavalent Chromium Abstract
- OSHA Offers Safety Tips for Tilt-Up Construction Abstract
- Physician's Alert: Skin Conditions
- Ready Mixed Concrete Truck Drivers: Work-Related Hazards and Recommendations for Controls
- Roadway Safety: Health Hazards Spanish
- A Safety & Health Practitioner's Guide to Skin Protection
- Save Your Skin
- What Physicians Need to Know About Occupational Silicosis and Silica Exposure Sources
- What Physicians Need to Know About Silicosis in Construction, Demolition, and Renovation Workers

The site started with 475 documents and has grown to 836 documents. A Spanish language version (http://www.cdc.gov/elcosh/Spanish/index.html) was launched with 150 documents in 2001. Smaller numbers of materials in Creole, French, Italian, Polish and Portuguese have been added since then. Improvements include streaming technology so that videos/DVDs can be viewed.

Solutions Database

The *Solutions Database* was developed to respond to the needs of contractors, supervisors and workers in the field who want immediate and accurate information when confronted with a problem. The database, still in development at the Construction Center, provides Internet-accessible and user-friendly answers to occupational hazards in the construction industry and ways to correct or control them. Whereas eLCOSH provides a platform for organizing existing

available construction safety and health materials, the *Solutions Database* effort involves identifying interventions and controls objectively demonstrated to be effective, describing them in practical end user terms, and organizing them by hazard and task. Thus it involves generating content from peer-reviewed literature and other available information. The project grew out of a trade-based exposure databank for dermal hazards and has involved developmental work to populate the database prior to launch. The success and value of the database for users will depend on having sufficient coverage for hazards and controls for a given work activity or trade so the database will be launched in phases as various sections are completed. The database is also being designed to support and encourage construction user feedback and suggestion of other solutions. The Construction Center researchers are coordinating closely with other colleagues working on similar databases – such as a NIOSH group developing a general *Solutions Database* for small businesses and colleagues working on similar databases in other countries (Australia, UK, Netherlands). A prototype featuring hazards and controls for "Masonry, Cement, and Plaster" work activities is being used for focus group testing and is shown in Figure 4.5.4

Figure 4.5.4 Solutions Database Prototype home page

Using communications science to inform diffusion
The Construction Program is increasingly using communication theories to diffuse our research products into the construction workplace. We encourage construction researchers to collaborate with communications professionals and have used meeting opportunities to provide diffusion and communications science tutorials to Program and Center researchers. Supported researchers at the University of Oregon have applied communications science to diffusion of ergonomic innovations and are developing specific messages and strategies for targeting various construction audiences from “innovators” to “early adopters” to “early majority” groups.

In another project, Construction Center researchers developed a ladder safety DVD and 4 tip sheets for construction workers. The 11-minute DVD, *Don’t Fall for It!*, mixes interviews with survivors of falls (or victims’ survivors) and information about safe procedures. Center researchers, working with the New Jersey Building and Construction Trades Council and the New Jersey Department of Health and Senior Services, developed a pilot program to evaluate the DVD’s impact on workers. Results showed significant changes in self-reported knowledge, attitudes and behavior among viewers. By June 2006, nearly 500 construction workers across the construction trades in New Jersey were shown the DVD. Due to the success of the pilot project in New Jersey, the Center began a campaign to disseminate the DVD using standard practices and also began reaching out to new users.

In 2006, Construction Center researchers began to explore the use of social marketing principles to promote the use of the fall protection DVD. The researchers selected small contractors and their employees as a target group. Center researchers contracted with social marketing experts to assist with an analysis of target audiences and development of social marketing plans.

In 2007, Center researchers presented to faculty and students at the George Washington University School of Public Health on the problems of ladder falls in construction. Faculty and students began a project to develop a social marketing campaign targeting the problem of ladder falls among small residential contractors. They surveyed the target audience using a telephone survey to identify contractors’ fall prevention activities and barriers to implementation. The information will be used to develop marketing ideas for reaching this population.

Several other studies now underway are described in “What’s Ahead.”

C) Outputs and Transfer:
(A general listing of outputs is included in Appendix 4.5A.)

(eLCOSH) electronic Library of Construction Occupational Safety and Health

The Construction Center publicized the site using a variety of approaches. It was launched at a major Construction Safety Council conference. Promotional fliers and posters were mailed to 3,000 in the Center's newsletter. A seven-minute introductory CD on the site was developed, and 150 copies were distributed to unions, safety and health trainers and others. Presentations on eLCOSH were made to union leaders, safety and health professionals and trainers, both nationally and internationally. The Center produced four public service announcements in English and Spanish to promote eLCOSH. They ran for four days in 2006 on radio stations in major metropolitan areas such as New York, Los Angeles, Chicago, San Francisco, Dallas, Washington, D.C., Houston, and Miami. They also ran in smaller markets such as Tucson, Austin, San Antonio, and Mexican-border towns. The possible listening audience for the combined markets was 13.8 million people.

Articles on eLCOSH such as "A Web-based resource for construction safety and health," [Seegal and Benjamin, 2002] were published in a peer-reviewed industrial hygiene journal, along with an article in *Environmental Health Perspectives* in March 2002.

Since the site launched in 2000, it has seen a steady increase in the number of users and page hits. The first year of its operation, eLCOSH had nearly 600,000 hits. By the second year, hits totaled just under 1 million. The site continued to grow and now surpasses 2 million hits annually.[8]

As of February 2007, 695 outside Web sites link to the eLCOSH home page. While no research has been done to track the number of sites that link to a specific subpage on a topic or document, we project that thousands more links exist. A casual Google search found more than 14,000. As of December 2006, eLCOSH linked to 63 sites of safety and health-related organizations.

Safety and health organization links include international sites and eLCOSH attracts a significant number of international visits. For example, for the period June 2006 through October 2006, visitors from 49 foreign nations used the site. Of the 706,096 pages viewed during that period, 8.3% were from visitors based in Spain. Mexico was second with 5.5% of pages viewed. The Spanish-language documents are popular. By March 31, 2006, 7 of the 20 top pages (35%) and 6 of the 20 top entry pages (30%) were Spanish. The CDC Spanish Web master, Pan American Health Organization Web site, and the new Spanish Web site of the state of Washington's OSHA plan, among others, are linking to eLCOSH and/or eLCOSH Spanish documents.

[8] Due to CDC server issues, some visitor count information was not collected during several months so the reported number is an undercount. Note also that the current omniture software used by CDC undercounts total hits because it does not count PDF files. eLCOSH has hundreds of PDF pages.

Solutions Database
The output of the *Solutions Database* is the site itself and its information content. Center researchers now have a prototype available for viewing on a secure Web site while beta testing is conducted.

Using communications science to inform diffusion
While our work in this area is relatively recent and several projects are still underway, the University of Oregon team has already authored a journal article, *A Roadmap to Diffuse Ergonomic Innovations in the Construction Industry: There is Nothing So Practical as a Good Theory* [Weinstein, et al. 2007].

Seven presentations describing the results from the New Jersey ladder safety pilot project and a demonstration of the *Don't Fall For It!* DVD have been made over the past year. The presentations were to groups such as the Massachusetts Building Trades Apprenticeship and Training Committee, the Construction Safety Roundtable, and the National Association of Union Constructors' Safety/Labor Forum.

Several intermediate customers using the DVD are The Construction Institute, in Boston. It is using the DVD throughout the Massachusetts Building Trades apprenticeship and training program, and the Occupational Health Program at the Massachusetts Department of Public Health. The director of the Occupational Health Program in the Department of Public Health previewed the DVD with the Interagency Group on Fall Prevention, which consists of representatives from state, federal and academic institutions throughout the state. In addition, 75 contractors attending the Liberty Mutual Construction Safety Roundtable received a copy of the DVD for use in their organizations.

D) Intermediate Outcomes

electronic Library of Construction Occupational Safety and Health (eLCOSH)
The site has been featured in at least eight magazines or Web sites. For example the *Engineering News Record* ran an article titled "New Website targets construction" in August of 2000 [Winston 2000]. It was also covered in professional journals read by researcher such as Environmental Health Perspectives [Dooley, 2002]. NIOSH, OSHA, and other Web sites highlight eLCOSH as a link.

One union reported that they found eLCOSH to be "a quick and thorough reference point for our officers and members" and that they used materials from the site in union articles and programs. They also reported that, "education on the health hazards has modified our members' and contractors' behavior, in terms of PPE made available and work habits. This information has also prompted locals in New Jersey and California to push for stricter safety

requirements, and prompted the inclusion of specific language on the dry-cutting of masonry products in many of our collective bargaining agreements."

Recognition has come from several outlets. The Web site was praised on the *Occupational Hazards* magazine Web site, www.occupationalhazards.com/articles/13013, as "the most comprehensive source of worker-focused construction safety and health information on the Web." The Construction Innovation Forum, a labor-management organization, contacted CPWR and requested that the organization submit an application for a NOVA award, which cites innovations in construction that improve quality and reduce costs. A Forum representative said that interest had been expressed in the Web site from around the country. Labor leaders from the Republic of Ireland requested a presentation on the site when they visited the U.S. in June 2005. Some examples of recent comments are included in Figure 4.5.5.

Figure 4.5.5 - Recent comments from eLCOSH users

"Just want to say you have a great site for construction safety information. Keep up the good work, we all need your help. As the Apprenticeship coordinator with local #28 Heat and Frost Insulators – a Colorado/Wyoming, I was informed of your site by [name withheld] our International Director. I plan on using much of the information in our training. Thanks again for being there for the workers. "

"Love your website. Wondering if there is away [sic] to copy your slides and if this OK to do this for training purposes? Interested in some of your confined space presentations."

Below is an 2/22/07 email asking for permission to use information from the eLCOSH:

Hello <Researcher>:
My name is [name withheld] . I am president of Best Safety LLC. I have known and worked with [name of Construction Center researcher withheld] for several years and it is at his suggestion that I write to you. I am interested in reprinting the "Construction Ergonomics Checklist" I found on eLCOSH site. It was written by Scott Schneider, and Michael McCann, copyright 2004. I am writing an ergonomic paper for ROOFING CONTRACTOR magazine, for whom I am a safety columnist. I would like to include this checklist as an appendix w/credits and appropriate footnotes to CPWR. [Name withheld] told me you would be able to assist me with this project. Thank you for your attention in this matter.

The "contact us" section on the site also leads to intermediate outcomes via email requests for assistance. Approximately 150 emails are received each year from construction workers, contractors, business owners, safety and health trainers or officers, student researchers in universities, private citizens, and spouses of ailing construction workers. Requests came mostly from the United States, although there were emails from India, Indonesia, Ghana, Dubai (UAE), Spain, Ireland, the UK, and even from a Sri Lankan worker who had been exposed to toxins in paint working for a company in South Korea.

eLCOSH is also used by union safety and health master trainers who then train instructors serving hundreds of thousands of building trades workers. At a recent meeting, safety and health representatives for six international unions relayed their union's use of eLCOSH. OPCMIA (Cement Masons union) instructors discuss eLCOSH when teaching OSHA 500 classes. Many other instructors see it as another important Web resource. International representatives reported that eLCOSH was easy to use and hoped their union's Web site was linked to eLCOSH.

The site has also become important for union members seeking college degrees through the National Labor College in Silver Spring, Md. Sixty percent of all students in the Bachelor degree program are from Building and Construction Trades Department unions. Students taking the courses must write a research paper to graduate, and they use eLCOSH as a research tool to complete the paper. Approximately 35 students have presented their findings annually at the American Public Health Association conference.

Solutions Database

The Solutions Database is still at the prototype stage.

Using communications science to inform diffusion

The Construction Program and Construction Center continue to explore and evaluate new ways to use communications science to improve results. Although some ventures are relatively new, they have produced intermediate outcomes.

In just one year, more than 2,200 copies of the *Don't Fall For It!* DVD have been distributed nationwide through various channels. Promotional efforts, such as showing the DVD at a Building and Construction Trades Conference display, have elicited requests for the DVD that have been distributed to instructors, master trainers, and other union members. Trainers/instructors reach tens of thousands of workers. For example, an IBEW (electricians' union) safety trainer instructed 250 people, mostly apprentices, using the Center's *Don't Fall For It!* DVD. A safety film/video lending library in Washington State OSHA that received the DVD in April 2006 reported that the DVD has been shown 22 times to 234 users, with four borrowers waiting to use it. During a national conference on immigrant workers in construction, Hispanic organizers requested the DVD to show to members of the Laborers Union in Southern California, as it has a dubbed version in Spanish, plus Spanish-language fliers. An article highlighting the DVD appeared in the Laborers International Union's health and safety fund newsletter, *Lifelines*. The Construction Safety Council requested that text from one of the DVD's instruction fliers, "Choosing and Inspecting Ladders," appear in their *Executive Safety Update* for January 2007.

In December 2006, researchers contacted the Director of the Massachusetts Occupational Health Program of the Massachusetts Department of Public Health

and the Director of the Construction Institute in Boston to discuss ideas for social marketing projects on fall prevention/ladder safety. It was determined that there might be interest in incorporating the *Don't Fall for It*! DVD into Ladder Safety Curriculum in Vocational Technical Schools in Massachusetts, and that the Apprenticeship and Training Directors of the Building and Construction Trades could also assist in development of a supplemental guide for young workers. The University of California Berkeley Labor Occupational Health Program has also adopted it for use in their new OSHA 10 curriculum for teen workers.

Regional OSHA offices in Washington State, Massachusetts, and Rhode Island have begun to incorporate the DVD into OSHA 500 training. Their efforts will reach thousands of workers. Fifty master instructors for the National Institute of Environmental Health Sciences Hazardous (NIEHS) Waste Training Courses received the DVD in 2006, and are incorporating it into their Train the Trainer (OSHA 500) courses nationwide. Their efforts reach 40,000 workers a year.

Our researchers are seeking avenues to get their research findings translated and presented to mass audiences. One Center researcher's report on nail gun injuries and prevention was published in the CDC's widely-read *Morbidity and Mortality Weekly Report.* That report was used by the *Washington Post* for an article in the Health section on nail gun injuries that referenced the Center consortium partner's research. The lead author of the "Roadmap to Diffuse Ergonomic Innovations" article was invited by the NIOSH Office of Health Communications to present findings at a 2007 retreat for NIOSH communications professionals.

External Factors

A factor that inhibits direct use of eLCOSH on construction sites is that computers and PDAs with internet access are still fairly uncommon. Site superintendents increasingly have internet access, but it is rarely extended to foremen and workers. Without internet access, potential eLCOSH users must wait until they are at home or in an office to use the site. An assessment based on the 2000 Current Population Survey supplement found 52.5% of the construction workforce have computers at home, and 29.9% access the internet from home, but only 8.6% accessed the internet from their work location [Platner & Dong 2002]. Center researchers believe that with the advance of technology, we may see an increased use of Web-friendly tools, such as PDAs and next generation cell phones, on construction sites that will enable workers, foremen, supervisors, contractors and engineers to search eLCOSH for answers to safety and health problems.

F) What's Ahead?

eLCOSH

The eLCOSH site offers opportunities for expanding dissemination of information to building trades workers, contractors and others. With the advent of new media

and technologies, online access to information will increase. We intend to add more materials to the “Training” section. We also have plans to develop an image library of photos and illustrations. We plan to search out more international documents and include more S&H practitioners worldwide as participants. We plan to conduct an eLCOSH users survey. Simplifying information, along with the image library, may help attend to the needs of low-literacy workers.

Knowing that technology’s use continues to expand and spread, we want to adapt information (and create pieces) using new media, such as short video pieces and MP3 files. We heard from Center master trainers in 2006 that they need short video clips to start discussions or illustrate safety points. New technology may expand the reach of our efforts – and may engage younger workers.

Solutions Database

More beta testing of the site is planned through email questions to 500 construction safety instructions and a partner group of participating contractor associations. Additional segments of the database addressing hazards and solutions in other construction operations will be added as records of task hazards and solutions are finalized. At the present time, Center researchers intend to launch the masonry section in summer of 2007 to industry press and union communicators. The Center will also prepare presentations and articles about Solutions for publication in journals, trade magazines, union publications and other media, as identified. An email campaign with a link to the *Solutions* Web site is also being explored.

Communication science

The NIOSH in-house study “Improving the Adoption and Diffusion of Ergonomic Interventions by Concrete Construction Contractors” is developing marketing plans for two underused ergonomic interventions. The Center study, “TAPS: Strategies for Diffusing Control Technologies for Masonry Tools” will disseminate a silica control certification program for masonry restoration contractors. Another study, “Safety Training and Safety Campaigns Across Three Regions” is looking at how to tailor safety campaigns to construction worker and contractor representatives, and how to evaluate the effectiveness of safety campaigns for increasing knowledge and awareness about construction safety barriers.

A Center researcher in Arizona managing an analysis of crane and aerial lift hazards is disseminating information from actual litigation files. He hopes to see contractors overcome the barriers of increased up-front costs of retro-fitting equipment when they realize the desired cost effectiveness can be achieved by reducing lost-time accidents, damage to equipment and property, and eliminating of the threat of third-party liability lawsuits. The researcher plans to do outreach and evaluation through training programs with individual in-house evaluation forms, as well as the standard channels of dissemination – presentations, peer-review journals and articles in industry publications and union magazines.

Another Center researcher is investigating safety culture, partnering with three union locals in geographically distinct areas. He is creating a “safe talk” training program to promote safety climate and foster safety attitudes and behaviors, fostering the culture to share near-miss experiences, provide and receive feedback about safety issues, and resolve work conflicts. Although obvious barriers exist, the researcher has testimonials of contractors in focus groups that they recognize the need for this training and practice.

A Center researcher has completed evaluation of a new system to prevent injuries due to falls that occur at the “leading edge” during decking installation in steel buildings and found the new system effective in limiting falls to a short distance, allowing self-rescue without injury. His new challenge is to convince contractors to use this new fall protection system. He will soon complete a DVD and workbook, which will be piloted with a steel erection contractor in the fall of 2007.

The NORA Construction Sector Council has identified research to practice and diffusion issues as important topics for discussion.

References

Dooley E. [2002]. Electronic Library of Construction Occupational Safety and Health. Environmental Health Perspectives, Volume 110, Number 3, March 2002.

Platner, JW and Dong, X. [2002]. Impacts of Digital Information Networks on Construction Contractors & Unions. *Journal of Labor Research*, Fall 2002, 23(4):575-589

Seegal, J and Benjamin, S. [2002] A Web-Based Resource for Construction Safety and Health. *Applied Occupational and Environmental Hygiene,* 17(4): 244-46

Weinstein M, Hecker S, Hess J, Kincl L. [2007] A Roadmap to Diffuse Ergonomic Innovations in the Construction Industry: There Is Nothing So Practical as a Good Theory. *Intl J Occup Environ Health*, 13:46-55.

Winston S, Ichniowski T [2000]. New Website targets construction. *Engineering News Record*, p. 11, August 28, 2000.

Appendix 4.5A

Outputs

eLCOSH

Journal articles

Seegal J and Benjamin S [2002]. A Web-Based Resource for Construction Safety and Health. Applied Occupational and Environmental Hygiene, 17(4): 244-46

Presentations and Other

Seegal J, Office of Environment, Safety and Health, DOE [2000]. eLCOSH: A New Resource on Construction Safety and Health in Environment, Safety and Health Information Portal. http://tis.eh.doe.gov/portal/feature/elcosh.html (Accessed 10/19/00)

Public Service Announcements (PSAs) -Four PSAs in English and Spanish to promote eLCOSH, created and produced by CPWR, ran four days (4/3/06, 4/19/06, 7/11/06, 7/20/06) on radio stations in major metropolitan areas, such as New York, Los Angeles, Chicago, San Francisco, Dallas, Washington, D.C., Houston, and Miami, as well as smaller stations in Tucson, Austin, San Antonio, and Mexican-border towns. Possible listening audience: 13.8 million people.

-eLCOSH CD. A seven-minute CD providing a general introduction to eLCOSH's content and how to use the site. (150 copies of the CD were distributed to unions, safety and health trainers and others)

An updated 14-slide eLCOSH presentation in Power Point was produced during the reporting period 2005-2006. The presentation, in English and Spanish, is available on eLCOSH

The above presentation was requested for use by the International Union of Operating Engineers and was presented in March 2006 to the Construction Section, ISSA XXVIII International Symposium, in Rio Vermelho, Salvador, Brazil.

Numerous additional presentations and demonstrations include the following:
-Construction Safety Council winter conference, 2001
-Promoted site using the introductory eLCOSH CD at the International Social Security Association's Construction Section in Paris, December 2001.
-Distributed promotional materials at A Partnership in Safety, Labor-Management Construction Safety Alliance, Randolph, Mass., March 1-3, 2005, and at the

Genesee Valley Safety Conference, Rochester, N.Y., October 2004, among others.
-Continued publicizing of eLCOSH as annual conferences including: BCTD Legislative Conference; Construction Safety Council; Selected union conferences; Trade association conventions for safety and health and for builders.

Solutions database
A seven minute introduction and prototype is available at http://www.cpwr.com/service-constructionsol.html

Using Communication Science
(Most of this work is ongoing)

Weinstein M, Hecker S, Hess J, Kincl L. [2007] A Roadmap to Diffuse Ergonomic Innovations in the Construction Industry: There Is Nothing So Practical as a Good Theory. *Intl J Occup Environ Health*, 13:46-55.